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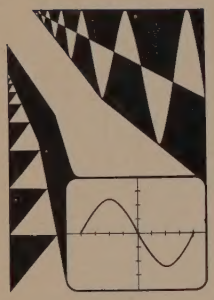

Portable h.f. dual-trace oscilloscope

SERVICE

PM3240

9499 440 15202

751130/1/02/03

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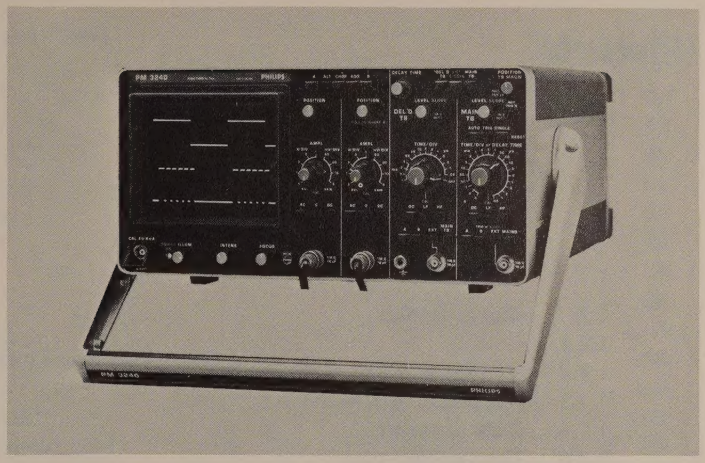

Operating manual

Portable h.f. dual-trace oscilloscope

PM3240

PHILIPS

Order no. of
this manual
9499 440 15202

751130/1/02/03

Contents

1.	**GENERAL INFORMATION**	9
1.1.	Introduction	9
1.2.	Characteristics	10
1.2.1.	C.r.t.	10
1.2.2.	Vertical or Y axis	10
1.2.3.	Horizontal or X axis	10
1.2.4.	Main time-base	10
1.2.5.	Delayed time-base	10
1.2.6.	External X deflection	12
1.2.7.	Triggering of the main time-base	12
1.2.8.	Triggering of the delayed time-base	13
1.2.9.	Calibration unit	13
1.2.10.	Power supply	13
1.2.11.	Environmental capabilities	13
1.2.12.	Mechanical data	14
1.2.13.	Accessories	14
2.	**DIRECTIONS FOR USE**	17
2.1.	Installation	17
2.1.1.	Removing and fitting the front cover	17
2.1.2.	Mains adjustment and fuse	17
2.1.3.	Earthing	17
2.1.4.	Switching on	17
2.2.	Operating instructions	18
2.2.1.	Controls and sockets	18
2.2.2.	Preliminary settings	22
2.2.3.	Inputs A and B and their possibilities	22
2.2.4.	Triggering	23
2.2.5.	Time-base magnifier	24
2.2.6.	Use of the delayed time-base	24
3.	**SERVICE MANUAL**	57
3.1.	Description of the block diagram	57
3.2.	Circuit description	59
3.2.1.	Vertical deflection system	59
3.2.1.1.	Input stage	59
3.2.1.2.	Intermediate amplifier	60
3.2.1.3.	Channel selection logic	61
3.2.1.4.	Final Y amplifier	62
3.2.2.	Main time-base triggering	63
3.2.2.1.	Trigger input circuits and amplifier	63
3.2.2.2.	Trigger amplifier and multivibrator	63
3.2.2.3.	Auto-circuit	64
3.2.3.	Main time-base generator	64
3.2.3.1.	Sweep gating multivibrator	64

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3.2.3.2.	Switching transistor TS868 and TS869	64
3.2.3.3.	Sweep speeds	64
3.2.3.4.	Sawtooth take-off circuit	65
3.2.3.5.	Hold-off circuit	65
3.2.3.6.	NOT TRIG'D indicator	65
3.2.3.7.	Delay-time function	66
3.2.4.	Delayed time-base triggering	66
3.2.5.	Delayed time-base generator	66
3.2.5.1.	Sweep speeds	66
3.2.5.2.	Hold-off circuit	66
3.2.5.3.	Comparator	66
3.2.6.	X-Deflection selector and blanking switching circuits	66
3.2.6.1.	X-Deflection	66
3.2.6.2.	Blanking pulse switching circuit	67
3.2.7.	Pre-amplifier for external X-deflection	68
3.2.8.	X-amplifier	68
3.2.9.	C.R.T. circuits	68
3.2.9.1.	Z modulator circuit	68
3.2.9.2.	Focusing circuit	69
3.2.9.3.	H.T. Converter	69
3.2.9.4.	Calibration unit	70
3.2.10.	Power supply	70
3.2.10.1.	Mains rectifier and ripple eliminator	70
3.2.10.2.	Switching series regulator	70
3.2.10.3.	Chopper circuit	71
3.2.10.4.	Error sensing and regulator circuit	71
3.2.10.5.	Current limiting circuit	72
3.2.10.6.	Switching-on voltage-sensing circuit	72
3.2.10.7.	Secondary supply voltages	72
3.2.10.8.	Mains triggering opto-isolator	72
3.3.	Dismantling the instrument	73
3.3.1.	General information	73
3.3.2.	Instrument cover plates and screen bezel	73
3.3.3.	Knobs	73
3.3.4.	Time-base, trigger and X amplifier circuit board	73
3.3.5.	Z Amplifier circuit board	74
3.3.6.	Intermediate amplifier circuit board	74
3.3.7.	Final Y amplifier circuit board	74
3.3.8.	2 kV Convertor	74
3.3.9.	8 kV Multiplier	74
3.3.10.	Power supply circuit board	74
3.3.11.	Delay line	75
3.3.12.	Cathode ray tube	75
3.3.13.	Pushbutton switches	75
3.3.14.	Trigger source unit	76
3.3.15.	Attenuator unit	76
3.3.16.	Carrying handle	76
3.3.17.	Special tools	76
3.3.18.	Soldering micro-miniature semi-conductors	78
3.4.	Checking and adjusting	79
3.4.1.	Performance check	79
3.4.1.1.	Preliminary control settings	79
3.4.1.2.	Cathode-ray tube	79
3.4.1.3.	Vertical axes	79
3.4.1.4.	Main time-base generator	81
3.4.1.5.	Delayed time-base generator	83
3.4.1.6.	X Deflection	84

3.4.2.	Adjusting procedure	85
3.4.2.1.	Preliminary control settings	85
3.4.2.2.	Cathode-ray tube circuit	86
3.4.2.2.1.	Trace rotation	86
3.4.2.2.2.	Brilliance	86
3.4.2.2.3.	Brilliance ratio	86
3.4.2.2.4.	Focus and astigmatism	86
3.4.2.2.5.	Geometry	86
3.4.2.3.	Vertical deflection	86
3.4.2.3.1.	Gain - Channel A	86
3.4.2.3.2.	DC Balance - Channel A	87
3.4.2.3.3.	Gain - Channel B	87
3.4.2.3.4.	DC Balance - Channel B	87
3.4.2.3.5.	Polarity balance - Channel B	87
3.4.2.3.6.	Input attenuators	87
3.4.2.3.7.	Square-wave response - Channel B	88
3.4.2.3.8.	Square-wave response - Channel A	89
3.4.2.4.	Triggering	89
3.4.2.4.1.	Main TB trigger level and DC balance of X amplifier	89
3.4.2.5.	Horizontal deflection	89
3.4.2.5.1.	Main time-base	89
3.4.2.5.2.	Linearity and horizontal positioning	90
3.4.2.5.3.	Delayed time-base	90
3.4.2.5.4.	X Deflection with the mains frequency	91
3.4.2.6.	Calibration unit	91
3.5.	Test and repair hints	97
3.5.1.	General information	97
3.5.2.	Y-amplifier	97
3.5.3.	Time-base and X-amplifier	97
3.5.4.	Instability	97
3.6.	Maintenance	97
3.7.	Parts lists	98
3.7.1.	Mechanical parts	100
3.7.2.	Electrical parts	105

FIGURES

1.1.	Portable v.h.f. dual-trace oscilloscope PM 3240	9
1.2.	Derating of the maximum permissible input voltage as a function of frequency	15
1.3.	Typical trigger sensitivity of channel A as a function of frequency	15
2.1.	Removing the front cover	16
2.2.	Rear view of the instrument	16
2.3.	Front view of the instrument	19,21
2.4.	Scanning the waveform by means of the LEVEL potentiometer	24
3.1.	Block diagram	57
3.2.	Unit location, top view	73
3.3.	Unit location, bottom view	73
3.4.	Removing the knobs	73
3.5.	Replacing a switch-segment of a push-button set	75
3.6.	Push-button set clamping device	75
3.7.	Tool for attenuator switches	77
3.8.	Tool for Position and Level potentiometers	77
3.9.	Dimensional drawings SOT-23 and SOT-43	78
3.10.	Effective signal delay	81
3.11.	Phase difference in X-Y mode	85
3.12.	Waveforms in the power-supply unit	95

3.13.	Adjustments points, top view	95
3.14.	Adjustment points, bottom view	95
3.15.	Mechanical parts, front view	101
3.16.	Mechanical parts, rear view	101
3.17.	Mechanical parts, top view	103
3.18.	Mechanical parts, bottom view	103
3.19.	Electrical item numbers, front panel	104
3.20.	Y-attenuator circuit diagram	121
3.21.	Y-attenuator assembly	121
3.22.	Y-attenuator p.c. board	122
3.23.	Circuit diagram attenuator impedance converter	122
3.24.	Circuit diagram intermediate Y amplifier	123
3.25.	Circuit diagram channel selection logic	124
3.26.	Intermediate Y amplifier p.c. board	125
3.27.	Circuit diagram final Y amplifier	126
3.28.	Final Y amplifier p.c. board	127
3.29.	Circuit diagram trigger unit	129
3.30.	Circuit diagram time-base unit	130
3.31.	Trigger unit p.c. board	131
3.32.	Time base switches	132
3.33.	Time base and X-amplifier p.c. board	133
3.34.	Circuit diagram X amplifier	134
3.35.	Circuit diagram Z unit and calibration unit	135
3.36.	Z unit and calibration unit p.c. board	136
3.37.	Circuit diagram EHT converter	137
3.38.	EHT converter p.c. board	137
3.39.	Circuit diagram power supply	138
3.40.	Power supply p.c. board	139
3.41.	Dummy load for power supply	140
3.42.	Cable lay-out, top view	141
3.43.	Cable lay-out, bottom view	141
3.44.	Cable lay-out, rear view	142

Inhalt

1.	**ALLGEMEINES**	25
1.1.	Einleitung	25
1.2.	Technische Daten	26
1.2.1.	Elektronenstrahlröhre	26
1.2.2.	Vertikale oder Y-Achse	26
1.2.3.	Horizontale oder X-Achse	27
1.2.4.	Hauptzeitablenkung	27
1.2.5.	Verzögerte Zeitablenkung	28
1.2.6.	Externe X-Ablenkung	28
1.2.7.	Triggerung der Hauptzeitablenkung	29
1.2.8.	Triggerung der verzögerte Zeitablenkung	29
1.2.9.	Kalibriereinheit	29
1.2.10.	Speisung	29
1.2.11.	Umgebungseigenschaften	30
1.2.12.	Mechanische Daten	30
1.2.13.	Zubehör	30
2.	**GEBRAUCHSANWEISUNG**	33
2.1.	Inbetriebnahme	33
2.1.1.	Abnehmen und Aufsetzen der Abdeckhaube	33
2.1.2.	Netzspannungseinstellungen und Sicherungen	33
2.1.3.	Erdung	33
2.1.4.	Einschalten	33
2.2.	Bedienungsanleitung	34
2.2.1.	Bedienungsorgane und Buchsen	34
2.2.2.	Grundeinstellungen	38
2.2.3.	Eingänge A und B und ihre Möglichkeiten	38
2.2.4.	Triggerung	39
2.2.5.	Dehnung der Zeitablenkung	40
2.2.6.	Gebrauch der verzögerten Zeitablenkung	40
3.	**SERVICEANLEITUNG (nur aufs Englisch)**	61

ABBILDUNGEN

1.1.	Tragbarer Zweistrahl-Oszillograf PM 3240	25
1.2.	Minderung der höchstzulässigen Eingangsspannung	31
1.3.	Typische Empfindlichkeit für interne Triggerung	31
2.1.	Abnehmen der Abdeckhaube	32
2.2.	Rückansicht des Gerätes	32
2.3.	Vorderansicht des Gerätes	35,37
2.4.	Abtasten der Wellenform mittels des LEVEL Potentiometers	40

Table des matières

1.	**GENERALITES**	41
1.1.	Introduction	41
1.2.	Caractéristiques techniques	42
1.2.1.	Tube à rayons cathodiques	42
1.2.2.	Axe vertical ou Y	42
1.2.3.	Axe horizontal ou X	43
1.2.4.	Base de temps principale	43
1.2.5.	Base de temps retardée	44
1.2.6.	Déviation externe X	44
1.2.7.	Déclenchement de la base de temps principale	45
1.2.8.	Déclenchement de la base de temps retardée	45
1.2.9.	Unité d'étalonnage	45
1.2.10.	Alimentation	45
1.2.11.	Possibilités d'application en rapport avec l'environnement	46
1.2.12.	Caractéristiques mécaniques	46
1.2.13.	Accessoires	46
2.	**MODE D'EMPLOI**	49
2.1.	Installation	49
2.1.1.	Démontage et montage du couvercle frontal	49
2.1.2.	Adaptation à la tension secteur et fusibles	49
2.1.3.	Mise à la terre	49
2.1.4.	Enclenchement	49
2.2.	Utilisation	50
2.2.1.	Commandes et prises	50
2.2.2.	Réglages préliminaires	54
2.2.3.	Entrées A et B et leurs possibilités	54
2.2.4.	Déclenchement	55
2.2.5.	Agrandisseur de base de temps	56
2.2.6.	Utilisation de la base de temps retardée	56
3.	**NOTICE DE SERVICE (seulement en anglais)**	57

FIGURES

1.1.	Oscilloscope double trace portatif PM 3240	41
1.2.	Réduction de la tension d'entrée maximale admise	47
1.3.	Sensibilités typiques pour déclenchement	47
2.1.	Dépose du couvercle frontal	48
2.2.	Vue arrière de l'appareil	48
2.3.	Vue avant de l'appareil	51,53
2.4.	Analyse de la forme d'onde à l'aide du potentiomètre LEVEL	56

1. General information

1.1. INTRODUCTION

The PM 3240 Portable h.f. oscilloscope enables the measurement of signals at a high sensitivity (5 mV/DIV) over a large bandwidth (50 MHz).

There is a wide choice of display possibilities, such as one channel, two channels alternately or chopped, two channels added, with normal and inverted position for one input signal, and a main and delayed time-base.

The PM 3240 oscilloscope features a tapless power supply with low dissipation. This power supply works on any a.c. mains voltage between 90 V and 264 V, or any d.c. voltage between 90 V and 200 V, thus obviating the need of adjusting the instrument to the local mains voltage.

All these features make the oscilloscope suitable for a wide variety of applications.

Fig. 1.1. Portable h.f. dual-trace oscilloscope PM 3240

1.2. CHARACTERISTICS

This specification is valid after the instrument has warmed up for 15 minutes. Properties expressed in numerical values with tolerances stated, are guaranteed by the manufacturer. Numerical values without tolerances are typical and represent the characteristics of an average instrument.

Designation		Specification	Additional information
1.2.1.	C.R.T.		
	Type	PHILIPS D14-125 GH/08	Rectangular tube face, mesh type, post-accelerator, metal-backed phosphor
	Measuring area	80 mm x 100 mm	
	Screen type	P31 (GH) phosphor	P11 (BE) and P7 (GM) phosphor optional
	Photographic writing speed	> 750 cm/μs	Measured with Steinheil Oscillophot M5 camera. Aperture: 1:1,2 Object to image ratio: 1:0,5 Film: Polaroid 410 (10000 ASA) No pre-fogging Phosphor type P31 (GH)
	Total acceleration voltage	10 kV	
	Graticule	Internal	Continuously variable illumination
	Engravings	Centimetre divisions with sub-divisions of 2 mm along the central axes. Dotted lines indicate 10 % and 90 % of measuring lattice for measurement of rise time	
1.2.2.	VERTICAL OR Y AXIS		
1.2.2.1.	*Response*		
	Frequency range	d.c. ... 50 MHz 10 Hz ... 50 MHz	–3 dB bandwidth d.c. coupled –3 dB bandwidth a.c. coupled
	Rise time	≈ 7 ns	
	Overshoot	± 2 %	Measured with a test pulse of 6 DIV, rise time 2 ns, frequency 1 MHz.
1.2.2.2.	*Deflection coefficients*	5 mV/DIV ... 2 V/DIV	Nine calibrated positions in 1-2-5 sequence. Uncalibrated continuous control 1 : $\geqslant 2,5$
1.2.2.3.	*Error limit*	± 3 %	
1.2.2.4.	*Max. permissible input voltage*	± 400 V	d.c. + a.c. peak. Up to 20 mV position of input attenuator derating at frequencies over 500 kHz. See Fig. 1.2.
1.2.2.5.	*Instability of the spot position*		
	d.c. drift	$< 0,3$ DIV/h	At 20°C in position 5 mV/DIV
	Temperature drift	$< 60\ \mu$V/°C	Typical value

Designation	Specification	Additional information
1.2.2.6. Maximum deflection		
Undistorted	24 DIV ⩾ 6 DIV	For sine waves up to 15 MHz For sine waves up to 50 MHz
Shift range	16 DIV	8 divisions each in topward and downward direction reckoned from the central horizontal graticule line
1.2.2.7. Input impedance	1 MOhm//15 pF	
1.2.2.8. Input RC time	≈ 22 ms	Coupling switch to AC
1.2.2.9. Visible signal delay	Approximately 20 ns	
1.2.2.10. Display modes	Channel A only Channel ±B only Channels A and ±B chopped Channels A and ±B alternate Channels A and ±B added	
1.2.2.11. Chopper frequency	≈ 1 MHz	
1.2.2.12. Cross-talk between channels	1 : 500	2 divisions of signal amplitude at 50 MHz on one channel set to .2 V/DIV. Cross-talk is measured on other channel set to 20 mV/DIV.
1.2.2.13. Common-mode rejection factor	100 at 1 MHz	Measure with +A and −B added, after adjustment: max. common mode signal 8 divisions
1.2.3. HORIZONTAL OR X AXIS		
1.2.3.1. Display modes	– Main time base – Main time base intensified by delayed time base – Delayed time base – XY Operation	X deflection by: – Channel A signal – Channel B signal – Signal applied to EXT connector of main time base – Mains frequency
1.2.4. MAIN TIME BASE		
1.2.4.1. Operation	Automatic Triggered Single shot	Possibility of automatic free-running in the absence of triggering signals
1.2.4.2. Time coefficients	0,5 s/DIV ... 50 ns/DIV	Twenty-two calibrated positions on 1-2-5 sequence. Uncalibrated continuous control 1 : ⩾ 2,5 between the steps
1.2.4.3. Coefficient error	±3 %	+5 °C ... +40 °C Sweep accuracy ±5 % in positions .5 and .2 s/DIV, and .1 and .05 μ/DIV

Designation	Specification	Additional information
1.2.4.4. Expansion		
Magnification	5 x	Switched, calibrated
Additional error	±2 %	
Max. effective time coefficient	10 ns/DIV	
1.2.5. DELAYED TIME BASE		
1.2.5.1. Operation	Delayed time base starts at option either immediately after the delay time, or is triggerable after the delay time	
1.2.5.2. Time coefficient	1 ms/DIV ... 50 ns/DIV	Fourteen calibrated positions in 1-2-5 sequence. Uncalibrated continuous control 1 ; ⩾ 2,5 between the steps
1.2.5.3. Coefficient error	±3 %	+5 °C ... +40 °C Sweep accuracy 5 % in positions .1 and .05 µs/DIV
1.2.5.4. Delay time	Continuously variable between approx. 0x and 10x the time coefficient of the main time base	
1.2.5.5. Delay-time jitter	< 1 : 20 000	
1.2.6. X DEFLECTION		
X Deflection via channel Y_A or Y_B		
1.2.6.1. Deflection coefficient	5 mV/DIV ... 2 V/DIV	Uncalibrated continuous control 2,5:1
1.2.6.2. Coefficient error	±10 %	
1.2.6.3. Bandwidth	0 ... 1 MHz	–3 dB bandwidth over 8 DIV
1.2.6.4. Input impedance	1 MOhm//15 pF	
1.2.6.5. Phase difference	⩽ 3° at 100 kHz	
External X deflection via EXT socket		
1.2.6.6. Deflection coefficient	⩽ 450 mV/DIV	Typical value 300 mV/DIV
1.2.6.7. Bandwidth	0 ... 1 MHz	–3 dB bandwidth over 8 DIV
1.2.6.8. Input characteristics	Identical to Y channels	
1.2.6.9. Phase difference	⩽ 3° at 100 kHz	
X Deflection with internal voltage at mains frequency		
The deflection depends on the mains voltage and has been factory-adjusted to 8 DIV at a mains voltage of 220 V.		
1.2.7. TRIGGERING OF THE MAIN TIME BASE		
1.2.7.1. Source	Internal from channel A Internal from channel B Internal from mains External source	Internally adjustable for different mains voltages

Designation	Specification	Additional information
1.2.7.2. Mode	Automatic	Automatic free-run of the time base generator approx. 100 ms after disappearance of the trigger signal.
	Manual level	
	Single sweep	
1.2.7.3. Slope	+ or –	
1.2.7.4. Sensitivity	Internal ⩽ 0,5 DIV	Typical 1/3 DIV
	External ⩽ 150 mV	Typical 100 mV
1.2.7.5. Filter bandwidth	DC: 0 - 50 MHz	Typical –15 dB bandwidth
	LF: 0 - 50 kHz	–3 dB, internal
	LF: 10 Hz - 50 kHz	–3 dB, external
	HF: 50 kHz - maximum	–3 dB, both internal and external
1.2.7.6. Level range		
Internal triggering	⩾ 16 DIV	Typical 24 DIV
External triggering	⩾ 4,8 V	Typical 7,2 V
1.2.7.7. Input characteristics	Identical to Y channels	

1.2.8. TRIGGERING OF THE DELAYED TIME BASE

1.2.8.1. Source	Internal from channel A	
	Internal from channel B	
	External	

Other characteristics are identical to TRIGGERING OF THE MAIN TIME BASE.

1.2.9. CALIBRATION UNIT

1.2.9.1. Output voltage	3 V_{p-p}	
1.2.9.2. Output current	6 mA	
1.2.9.3. Error limit	±1 %	Both voltage and current
1.2.9.4. Frequency	2 kHz ±2 %	
1.2.9.5. Protection	The output is protected against continuous short-circuits	

1.2.10. POWER SUPPLY

1.2.10.1. Mains voltages	Any voltage between 100 and 240 V ±10 % in one range (a.c.)	Any voltage between 90 and 200 V d.c.
1.2.10.2. Mains frequency	46 to 440 Hz, or d.c.	
1.2.10.3. Power consumption	23 W	

1.2.11. ENVIRNMENTAL CAPABILITIES

The environmental data are avlid only if the instrument is checked in accordance with the official checking pr procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS organisation in your country, or by N.V. PHILIPS' GLOEILAMPENFABRIEKEN, TEST AND MEASURING DEPARTMENT, EINDHOVEN, HOLLAND.

1.2.11.1. Ambient temperature	+5 °C ... +40 °C	Rated range of use
	–10 °C ... +55 °C	Limit range of operation
	–40 °C ... +70 °C	Storage and transport conditions
1.2.11.2. Altitude	5 000 m (15 000')	Operating
	15 000 m (45 000')	Not operating

Designation	Specification	Additional information
1.2.11.3. Humidity	The instrument meets the requirements of the IEC 68 Db recommendations	
1.2.11.4. Bump	1000 bumps of 10 g, ½ sine, 6 ms duration, in each of 3 directions.	
1.2.11.5. Vibration	30 minutes in each of three directions, 10-150 Hz; 0.7 mm p-p and 5 g max. acceleration.	
1.2.11.6. Recovery time	30 minuted for normal operation	Coming from −10 °C and going to +20 °C at 60 % relative humidity
1.2.11.7. Electromagnetic interference	The instrument meets the VDE, Störgrad K, requirements	

1.2.12. MECHANICAL DATA

1.2.12.1. Dimensions	Length 410 mm (16 1/4") Width 316 mm (12 1/4") Height 154 mm (6 1/8")	Excl. controls, cover and feet
1.2.12.2. Weight	8,4 kg (185 LBS)	

1.2.13. ACCESSORIES

1.2.13.1. Accessories delivered with the instrument

Contrast filter
Front cover with storage space
Collapsible viewing hood PM 9366
Banana - BNC adapter PM 9051
CAL terminal - BCN adapter
Manual

1.2.13.2. Optional accessories

PM 9335	Passive 1:1 probe
PM 9350	Passive 10:1 probe
PM 9347*)	Active t.v. probe
PM 9353*)	Active F.E.T. probe
PM 8960	Rack-mounting adapter
PM 8971	Camera flange
PM 8980	Long viewing hood
PM 9380	Oscilloscope camera
M3 ... M5	Oscilloscope camera range Steinheil Oscillophot

*) Auxiliary Probe Power Supply PM 9346 is necessary if these probes are to be used.

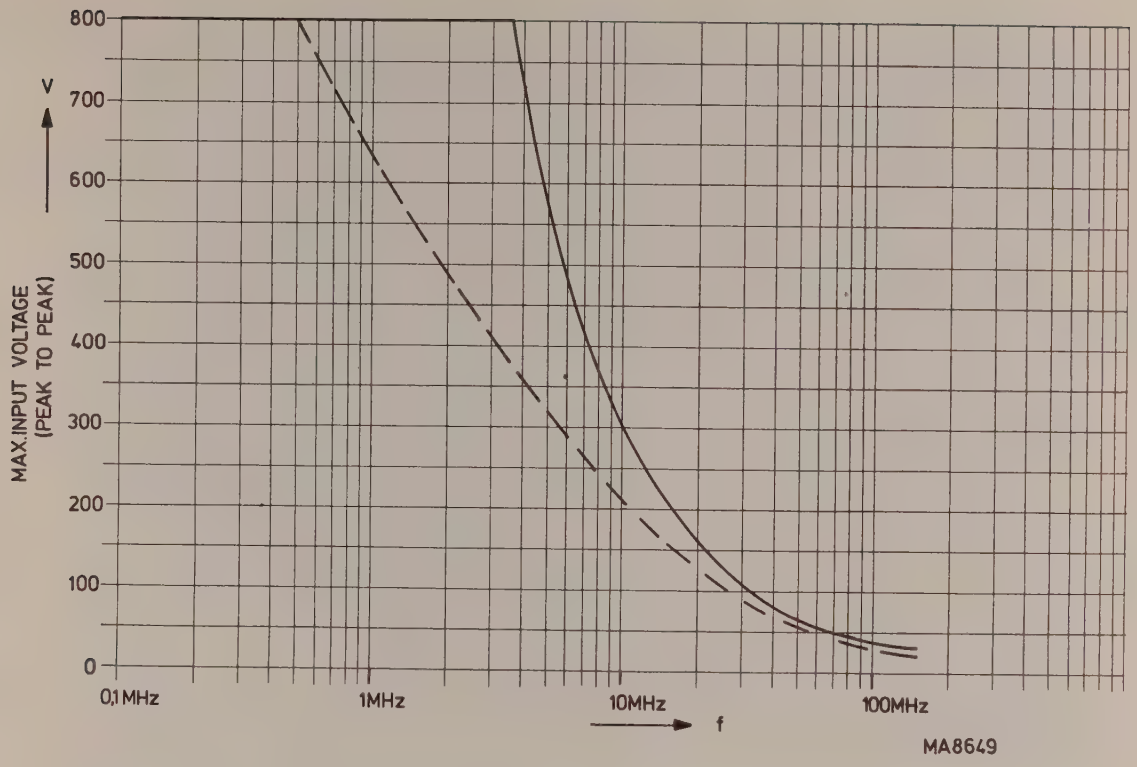


Fig. 1.2. Derating of the maximum permissible input voltage as a function of frequency

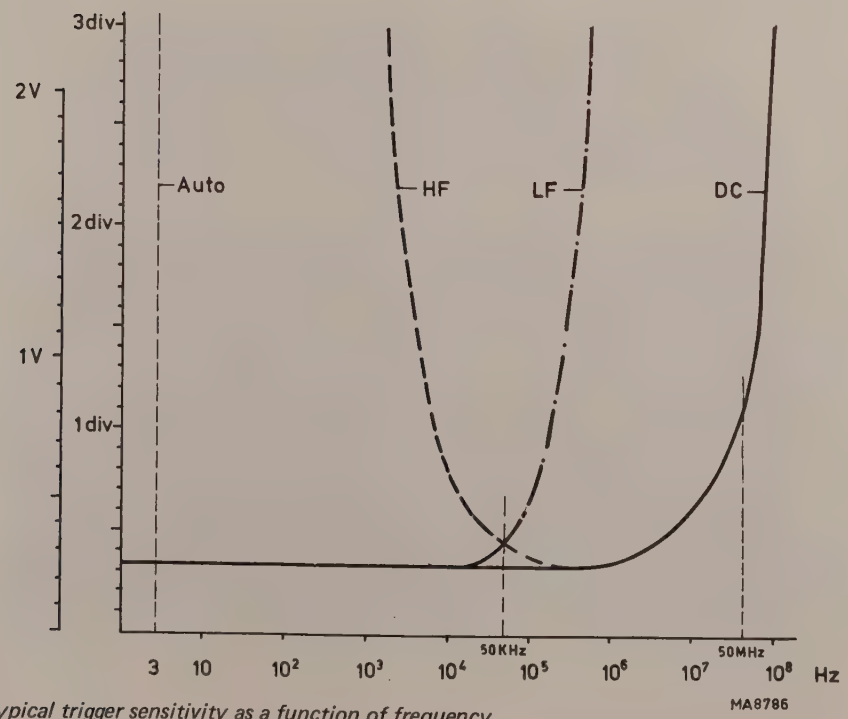


Fig. 1.3. Typical trigger sensitivity as a function of frequency

Fig. 2.1. Removing the front cover.

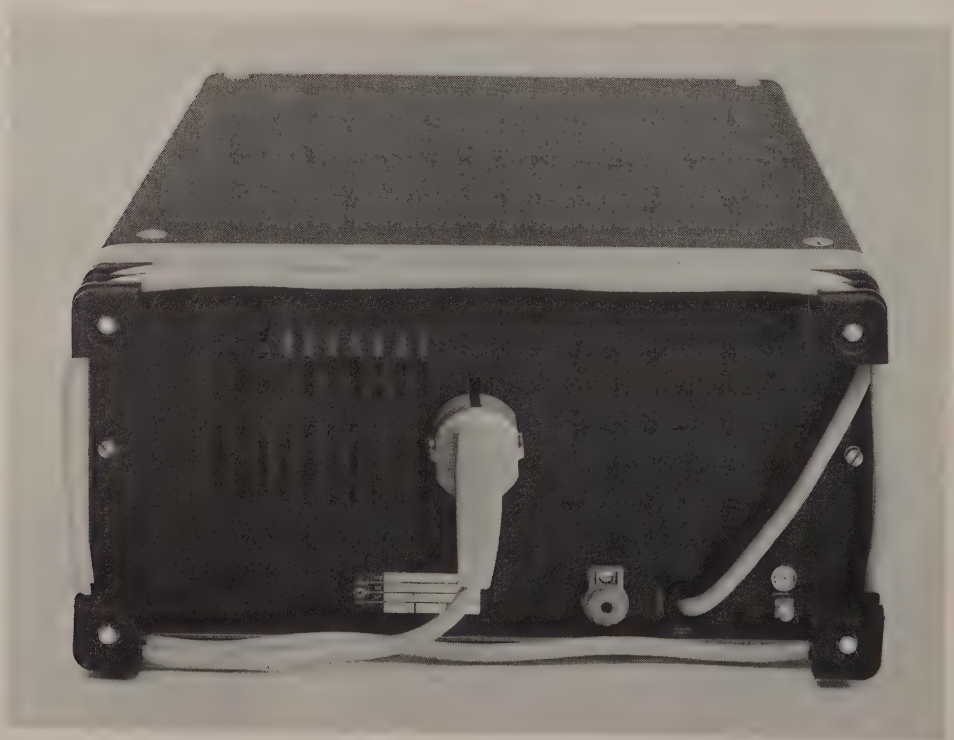


Fig. 2.2. Rear view of the instrument.

2. Directions for use

2.1. INSTALLATION

2.1.1. Removing and fitting the front cover

Removing: – Turn the knob in the centre of the cover a quarter of a turn anti-clockwise.
– Take the cover off.

Fitting: – Align the key of the locking knob with the slot in the text plate of the instrument.
– Fit the cover over the front of the oscilloscope.
– Press the knob and turn it a quarter of a turn clockwise.

Remark: The handle can be rotated if the push-buttons on its bearings are depressed.

Warning: This instrument generates high voltages and should not be operated with the cabinet plates removed. The mains plug must be removed before attempting any maintenance work, and any relevant high-voltage points discharged.

2.1.2. Mains adjustment and fuse

The ability of the instrument to operate at any mains voltage between 90 and 264 V a.c. or between 90 and 220 V d.c. obviates the need of adaptation to the local mains voltage.
The fuse holder which is mounted on the rear panel at 1,6 A delayed action fuse. The use of repaired fused and the short-circuiting of fuse holders is dangerous and should be avoided.

2.1.3. Earthing

In the interests of safety, the oscilloscope must be connected to earth via the rear earthing terminal (identified by the symbol ⏚) or via the mains lead, provided that the supply socket is equipped with an earth connection. Care must be taken that the earth line to the oscilloscope is not interrupted due to the use of an extension lead or device which is not fitted with an earth conductor.

2.1.4. Switching on

The POWER switch is incorporated in the graticule ILLUMination control on the front panel, immediately below the screen bezel. The oscilloscope must never be switched on whilst any circuit board has been removed. Never remove a circuit board until at least one minute after the oscilloscope has been switched off.

2.2. OPERATING INSTRUCTIONS

Before switching on, ensure that the oscilloscope has been correctly installed in accordance with section 2.1. INSTALLATION and that the precautions outlined have been observed.

2.2.1. Controls and sockets (Fig. 2.3.)

2.2.1.1. Vertical channels

A/ALT/CHOP/ADD/B	Display-mode controls; 5-way push-button switch.
A depressed	Vertical deflection is achieved by the signal connected to the input of channel A.
ALT depressed	The display is switched over from one vertical channel to the other at the end of every cycle of the time-base signal.
CHOP depressed	The display is switched over from one vertical channel to the other at a fixed frequency.
ADD depressed	Vertical deflection is achieved by the sum signal of channels A and B.
B depressed	Vertical deflection is achieved by the signal connected to the input of channel B. If no push-button is depressed, the instrument operates in the A or B mode.
POSITION	Continuously variable control giving vertical shift of the display.
PULL TO INVERT B	Push-pull switch incorporated in the POSITION control for the inversion of the signal polarity of channel B.
AMPL.	Step control of the vertical deflection coefficients; 9-way switch.
AMPL./CAL. (blue)	Continuously variable control of the vertical deflection coefficients. In the CAL. position the deflection coefficient is calibrated.
BAL (screw-driver operated)	Continuously variable control of the direct voltage balance of the vertical amplifiers.
GAIN (screw-driver operated)	Continuously variable control of the overall gain of the vertical channels.
AC/0/DC	Signal coupling; 3-way push-button switch.
AC depressed	Coupling via a blocking capacitor
0 depressed	Connection between input circuit and input socket is interrupted and the amplifier input is earthed
DC depressed	Direct coupling No button depressed has the same effect as the AC button depressed.
A 1 MOhm - 15 pF	BNC input socket for channel A
B 1 MOhm - 15 pF	BNC input socket for channel B

2.2.1.2. Horizontal channel

DEL'D TB - EXT. X DEFL - MAIN TB	Horizontal-deflection controls; 3-way push-button switch.
DEL'D TB depressed	The horizontal deflection voltage is supplied by the delayed time-base generator.
EXT. X DEFL depressed	Horizontal deflection is achieved by an external signal applied to the input socket of the horizontal amplifier, by the channel A signal, by the channel B signal or by a mains-frequency signal.

MAIN TB depressed	The horizontal deflection voltage is supplied by the main time-base generator. A part of the trace is intensified when the delayed time-base is running. The delayed time-base generator is switched off when the DELD TIME/DIV switch is in position OFF' No button depressed has the same effect as the MAIN TB button depressed.
POSITION TB MAGN	Continuously variable control giving horizontal shift of the display; incorporates a push-pull switch which increases the horizontal deflection coefficient by a factor of 5. The magnifier is inoperative if an external X deflection signal is used.

2.2.1.3. Main time-base generator

LEVEL SLOPE	Continuously variable control to select the level of the triggering signal at which the time-base generator starts. This control incorporates a push-pull switch which enables choice of triggering on the positive- or negative-going edge of the triggering signal.
NOT TRIG'D	Pilot lamp which lights up when the time-base generator is not triggered.
AUTO - TRIG - SINGLE	Trigger-mode controls; 3-way push-button switch.
AUTO depressed	The main time-base generator is free-running in the absence of triggering signals.
TRIG depressed	The time-base generator is normally triggered.
SINGLE depressed	After operating the SINGLE button, the time-base generator runs only once upon receipt of a trigger pulse. If no button is depressed, the instrument operates in the SINGLE mode. If you do not obtain a display when the instrument is switched on and an input signal has been connected, check that the AUTO or TRIG push-button in the MTB compartment has been depressed.

Fig. 2.3. Front view of the instrument

TIME/DIV or DELAY TIME	Time-coefficient control of the main time-base; 22 way rotary switch.
TIME/DIV - CAL (blue)	Continuously variable control of the time coefficient of the main time-base. In the CAL position the time coefficient is calibrated.
DC - LF - HF	Trigger coupling; 3-way push-button switch.
DC depressed	Triggering signals are direct-coupled.
LF depressed	Coupling via low-pass filter for frequencies up to 50 kHz (for external triggering via band-pass filter of 10 Hz - 50 kHz).
HF depressed	Coupling via a high-pass filter for frequencies higher than 50 kHz. No push-button depressed has the same effect as button DC depressed.
TRIG or X DEFL	Trigger source or external X deflection selector; 4-way push-button switch.
A depressed	Internal triggering or X deflection signal derived from channel A.
B depressed	Internal triggering or X deflection signal derived from channel B.
EXT depressed	Triggering on external signal connected to the adjacent 1 MOhm-15 pF socket. When the EXT X DEFL button of the horizontal deflection controls is depressed, this socket is connected to the input of the horizontal amplifier.
MAINS depressed	Triggering or X deflection signal derived from an internal voltage with the mains frequency. No push-button depressed has the same effect as button A depressed.
1 MOhm - 15 pF	BNC socket for external triggering or horizontal deflection.

2.2.1.4. Delayed time-base generator

DELAY TIME	Continuously variable control of the delay time, operating together with the TIME/DIV controls of the main time-base generator.
LEVEL SLOPE	Continuously variable control to select the level of the triggering signal at which the delayed time-base generator starts. This control incorporates a push-pull switch which enables choice of triggering on the positive- or negative-going edge of the triggering signal.
TIME/DIV	Time-coefficient control of the delayed time-base; 15-way rotary switch. Incorporates an OFF position in which the delayed time-base generator is switched off.
TIME/DIV - CAL (blue)	Continuously variable control of the time coefficient of the delayed time-base generator. In the CAL position the time coefficient is calibrated.

DC - LF - HF	Trigger coupling; 3-way push-button switch.
DC depressed	Triggering signals are direct-coupled.
LF depressed	Coupling via low-pass filter for frequencies up to 50 kHz (for external triggering via band-pass filter of 10 Hz to 50 kHz).
HF depressed	Coupling via a high-pass filter for frequencies higher that 50 kHz. No button depressed has the same effect as the DC button depressed.
A - B - EXT - MAIN TB	Trigger source and starting point of the delayed time-base; 4-way push-button switch.
A depressed	Triggerable, after delay time, on channel A signal.
B depressed	Triggerable, after delay time, on channel B signal.
EXT depressed	Triggerable, after delay time, on an external signal connected to the adjacent 1 MΩ//15 pF socket.
MAIN TB depressed	Delayed time-base starts immediately after delay time.
1 MOhm - 15 pF	BNC input socket for external triggering signal.

2.2.1.5. Cathode-ray tube

ILLUM POWER	Continuously variable control of the graticule illumination; incorporates mains switch. Pilot lamp indicated the ON state, a few seconds after switching on.
INTENS	Continuously variable control of the trace brilliance.
FOCUS	Continuously variable control of the electron-beam focusing.

2.2.1.6. Miscellaneous

CAL	Output socket on which a square-wave voltage of 3 V_{p-p} and a current of 6 mA at a frequency of 2 kHz are available. Amplitude accuracy: ±1 %. Frequency accuracy: ±2%. The output is protected against continuous short-circuits.
⏚	Measuring-earth socket.

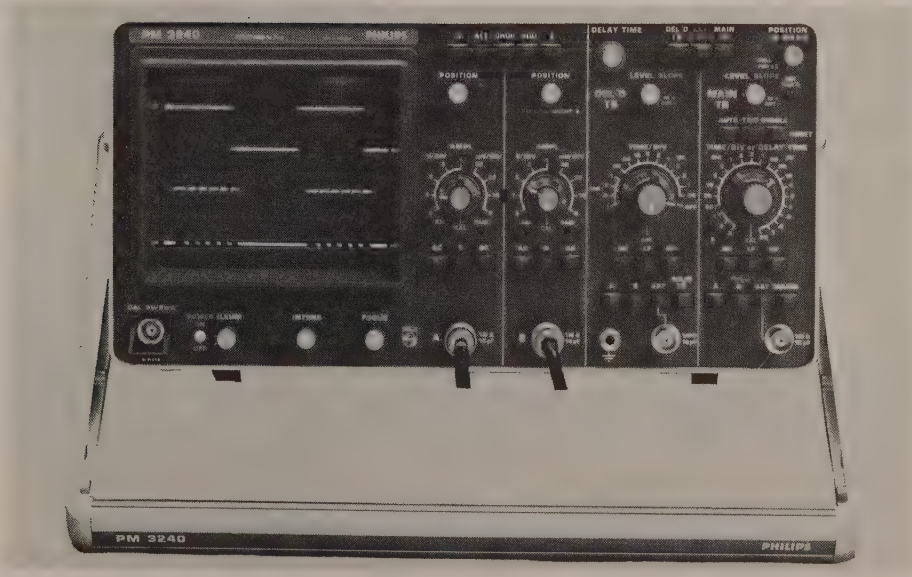


Fig. 2.3. Front view of the instrument

2.2.2. Preliminary settings

As the following settings are identical for both vertical channels, only the procedure for channel A has been indicated.

2.2.2.1. Adjusting the d.c. balance

- Operate push-button A of the display-mode controls.
- Operate push-button AUTO of the trigger-mode controls.
- Operate push-button A of the trigger-source controls.
- Operate push-button MAIN TB of the horizontal deflection controls.
- Set the AMPLitude switch to 5 mV and the continuous control to CALibrated.
- Centre the trace with the POSITION controls.
- Set the INTENSity and FOCUS controls for a sharp, well-defined trace.
  The controls not mentioned may occupy any position.
- Check that the trace does not jump when the AMPL switch is switched between the 5 and 10 mV positions.
  If necessary, readjust the BALance control on the front panel immediately below the AMPLitude control.

2.2.2.2. Adjusting the gain

Unless otherwise stated, the controls occupy the same position as in the previous adjusting procedure.

- Set the AC-0-DC switch to DC.
- Set the AMPLitude switch to .5 V and the continuous control to CALibrated.
- Connect the CALibration socket to the A input socket.
- Check that the trace height is exactly 6 divisions.
  If necessary, readjust the GAIN control on the front panel, immediately below the AMPLitude switch.

2.2.3. Inputs A and B and their possibilities

The oscilloscope has been provided with two identical channels, each of which can be used for either YT measurements in combination with one or both time-base generators, or XY measurements in combination with the external horizontal channel.

2.2.3.1. YT Measurements

To display one signal, either of the two vertical channels can be selected by operating either push-button A or push-button B of the display-mode controls.
When push-button ALT or CHOP is depressed, two different signals can be displayed simultaneously. The Y deflection coefficient and the polarity can be selected for each channel individually. When the ALT button is operated, the display is switched over from one channel to the other at the flyback of the time-base signal. Although the ALTERNATE mode can be used at all sweep speeds of the time-base generator, the CHOPPED mode will give a better display quality for long sweep times, because during these long sweep times the alternate display of the two input signals is clearly visible to the eye.

In the CHOPPED mode, the display is switched over from one channel to the other at a fixed frequency.
If push-button ADDED of the display-mode switch is operated, the signal voltages of both vertical channels are added. Depending on the position of the channel B polarity switch, either the sum or the difference of the input signals is displayed.

2.2.3.2. XY Measurements

If push-buttons EXT X DEFL of the horizontal-deflection controls and A of the TRIG OR X DEFL controls are operated, the time-base generators are switched off. A signal applied to the vertical A channel is then used for horizontal deflection. The AC/0/DC switch and the step attenuator of channel A remain operative. Continuous control of the deflection coefficients is possible with the continuous control AMPL and horizontal trace shift with the X POSITION control.

Vertical channel B may also be used for X deflection.
To this end, the B button of the TRIG OR X DEFL controls is depressed.

It is also possible to use an internal voltage at the mains frequency or a signal applied to the EXT socket at the bottom right-hand side of the front panel for X deflection, after depressing the relevant push-button of the TRIG OR X DEFL controls.

2.2.3.3. AC/0/DC switch

The signals under observation are fed to input socket(s) A and/or B and the AC/0/DC switch is set to either AC or DC, depending upon the composition of the signal. As the vertical amplifier is d.c. coupled, the full bandwidth of the instrument is available and d.c. components are displayed as trace shifts in the DC position of the AC/0/DC switch.
This may be inconvenient when small signals superimposed on high d.c. voltages must be displayed. Any attenuation of the signal will also result in attenuation of the small a.c. component. The remedy is to use the AC position of the input switch, which employs a blocking capacitor, to suppress the d.c. component. Some pulse droop, however, will occur when l.f. square-wave signals are displayed.

The 0 position interrupts the signal and earths the amplifier input for quickly determining the 0 V level.

2.2.4. Triggering

If a signal must be displayed, the horizontal deflection must always be started on one fixed point of the signal in order to obtain a stationary display. The time-base generator is, therefore, started by narrow trigger pulses formed in the trigger unit and controlled by a signal originating from one of the vertical input signals, an internal voltage at mains frequency or an external source.

2.2.4.1. Trigger coupling

Three different trigger-coupling methods can be chosen with the DC/LF/HF switch. In the HF and LF positions, the transfer characteristic is limited (see also curve on page 15.)
In position DC the trigger signal is passed unchanged.
In position LF, a 0 Hz (10 Hz for external triggering) to 50 kHz band-pass filter is inserted. This position can be used to reduce interference from noise.
In position HF, a 50 kHz high-pass filter is inserted.
This position can be used to reduce interference from e.g. hum.

2.2.4.2. Selecting the trigger source and setting the trigger level

The trigger signal is obtained from channel A (button A depressed), channel B (button B operated), an external source (button EXT depressed) or from an internal voltage at mains frequency (button MAINS depressed).
The trigger pulse shaper is a multivibrator switched by the output signal of a trigger amplifier.
The trigger signal, which is affected by the continuous AMPLitude control is, together with direct voltages which are adjustable with the LEVEL potentiometer, fed to the input of the trigger amplifier.
Depending on the LEVEL setting, a certain part of the trigger signal will be amplified by this amplifier.

The multivibrator is thus switched at a fixed point of the trigger signal (see Fig. 2.4.). This means that, with the aid of the LEVEL control, it is possible to scan the shape of the trigger signal (in case of internal triggering A or B equal to the shape of the signal to be displayed) and, thus, to choose the point where the multivibrator will be switched.
The LEVEL potentiometer is fitted with a push-pull switch which allows selection of the trigger slope.

2.2.4.3. Automatic triggering

When the AUTOmatic button of the AUTO-TRIG-SINGLE switch is operated, and if there are no trigger pulses available, the time-base generator is automatically free-running.
The trace is, therefore, always visible. The AUTOmatic mode can be used in all cases where also the TRIG mode is usable, except with signal frequencies lower than 10 Hz or pulse trains with an off time exceeding 100 ms.
As soon as trigger pulses are available, the free-running state of the time-base generator is automatically terminated and the time-base generator is triggered again as described in sections 2.2.4.1. and 2.2.4.2.
When the TRIGgered or SINGLE button is operated, the auto-circuit is switched off. The LEVEL setting can also be used in the AUTOmatic mode.

2.2.4.4. SINGLE sweep triggering

When effects which occur only once have to be observed (usually photographed), it is often desirable to ensure that only one sawtooth is generated, even though several trigger pulses might be produced after the phenomenon of interest. Of course, the single sawtooth in question must be triggered by a trigger pulse. To this end, the SINGLE button must be pressed. The first trigger pulse that appears after the button has been released will start the time-base generator.
The time-base generator is then blocked until the SINGLE button is pressed again. The NOT TRIG'D lamp will light up as soon as the SINGLE button has been released, until the trigger pulse arrives.

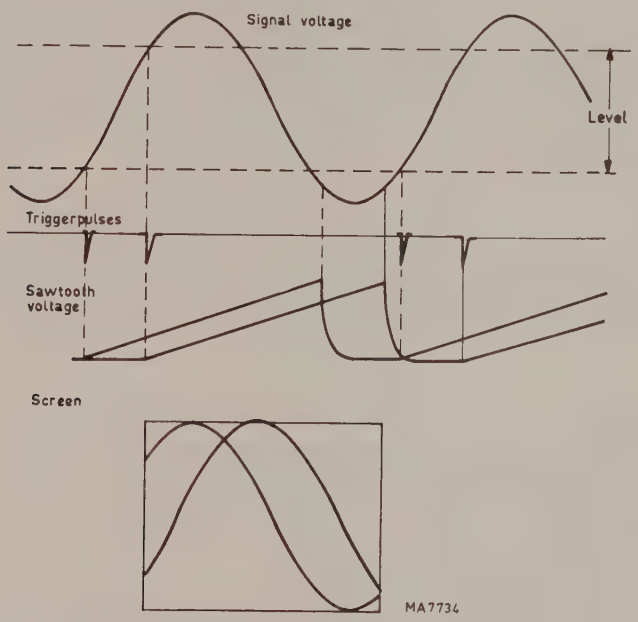


Fig. 2.4. Scanning the waveform by means of the LEVEL potentiometer

2.2.5. Time-base MAGNifier

The time-base magnifier is operated by a push-pull switch incorporated in the horizontal-POSITION control. If this switch is pulled to position x5, the sweep speeds of the main time-base generator are increased by a factor of 5. Thus, the portion of the signal displayed over a width equal to one division in the centre of the screen in the x1 position (T B MAGNifier depressed), will occupy the full width of the screen in the x5 position.
Any portion of the trace can be brought on to the screen by the horizontal-POSITION control for scrutinisation. In the x5 position, the time coefficient is determined by dividing the indicated TIME/DIV value by 5.

2.2.6. Use of the delayed time-base

The delayed time-base can be used for the accurate study of complex signals. When push-button MAIN TB of the delayed t.b. trigger-source controls is operated, immediately the delayed-time base is on (i.e. the TIME/DIV switch is not at OFF), a portion of the displayed signal is intensified in the MAIN TB position of the horizontal deflection controls. The DELAY TIME control enables this intensified portion to be shifted along the time axis. The duration of the intensified portion, its length, can be controlled in steps and continuously by means of the TIME/DIV controls of the delayed time-base generator. When push-button DEL'D TB of the horizontal deflection controls is operated, the intensified portion occupies the full width of the screen. In the DEL'D TB position, the delay time, (i.e. the interval between the starting point of the main time-base and the starting point of the delayed time-base) is determined by the settings of the main TIME/DIV controls and the DELAY TIME control.

If one of the other del'd t.b. trigger-source controls is operated, the delayed time-base is started by the first trigger pulse that occurs after the selected delay time. This trigger pulse is supplied by the trigger unit of the delayed time-base generator. This position is used when time jitter would otherwise give a blurred image of the detail under observation. This time jitter could be part of the signal being investigated or, at extreme magnifications, originate in the time-base circuits.

Bedienungsanleitung

1. Allgemeines

1.1. EINLEITUNG

Der tragbare Oszillograf PM 3240 gestattet Messungen von Signalen bei hoher Empfindlichkeit (5 mV/Teil) über eine grosse Bandbreite (50 MHz).

Es gibt eine grosse Auswahl von Darstellungsmöglichkeiten. Es können ein oder zwei Kanäle dargestellt werden. Die Addition beider Kanäle ist ebenfalls möglich.

Durch die Invertierungsmöglichkeit einer Kanal können auch Differenzen gebildet werden.
Der Oszillograf ist mit einer Hauptzeitablenkung und einer verzögerten Zeitablenkung ausgerüstet.

Der PM 3240 hat eine Speisung mit niedriger Verlustleisung, die bei jeder beliebigen Wechselspannung zwischen 90 V und 264 V betriebsfähig ist, wodurch sich eine Einstellung auf die örtliche Netzspannung erübrigt.

Durch all diese Eigenschaften eignet sich der Oszillograf für einen grossen Einsatzbereich.

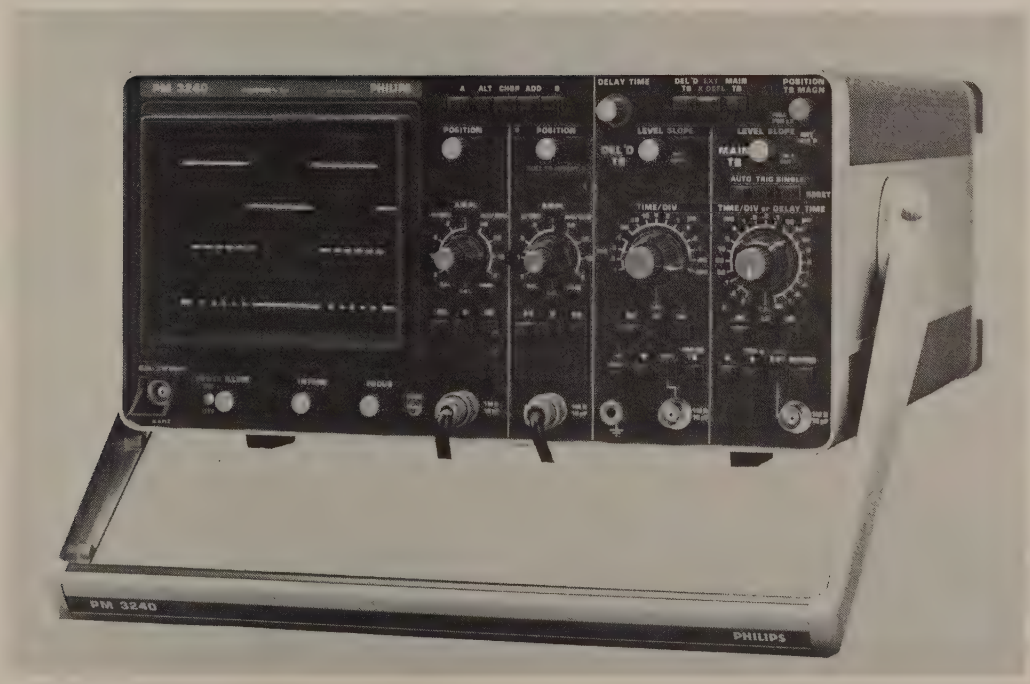


Abb. 1.1. Tragbarer Zweistrahl-Oszillograf PM 3240.

1.2. TECHNISCHE DATEN

Diese Spezifikation gilt nach 15 Minuten Anwärmzeit des Gerätes. Zahlenwerte mit Toleranzangabe werden garantiert. Zahlenwerte ohne Toleranzangabe geben die Eigenschaften eines durchschnittlichen Gerätes an und sind nur zur Orientierung.

Benennung	Beschreibung	Nähere Angaben
1.2.1. ELEKTRONENSTRAHLRÖHRE		
Typ	PHILIPS D14-125 GH/08	Rechteckiger Schirm, mit Netzelektrode und Nachbeschleunigung, metallhinterlegter Leuchtschirm.
Ausnutzbare Schirmfläche	80 mm x 100 mm	
Schirmtyp	P31 (GH) Phosphor	P11 (BE) und P7 (GM) Phosphor auf Wunsch lieferbar
Photografische Schreibgeschwindigkeit	> 750 cm/μs	Gemessen mit Steinheil Oscillophot M5 Kamera. Blende: 1:1,2 Bildausschnitt Verhältnis: 1:0,5 Film: Polaroid 410 (10000 ASA) Keine Vorbelichtung Phosphor Typ P31 (GH)
Gesamte Beschleunigungsspannung	10 kV	
Raster	Intern	Stufenlos einstellbare Rasterbeleuchtung
Einleitung	Zentimetereinteilung mit Untereinteilung von 2 mm an den mittleren Achsen. Gestrichelte Linien bei 10 % und 90 % des Messrasters, zur Messung von Anstiegzeiten	
1.2.2. VERTIKALE ODER Y-ACHSE		
1.2.2.1. Kennlinie		
Frequenzbereich	d.c. ... 50 MHz 10 Hz ... 50 MHz	–3 dB, Gleichspannungskopplung –3 dB, Wechselspannungskopplung
Anstiegzeit	≈ 7 ns	
Überschwingen	±2 %	Gemessen mit Testpulse von 6 Teilen, Anstiegzeit 2 ns, Frequenz 1 MHz
1.2.2.2. Ablenkkoeffizienten	5 mV/Teil ... 2 V/Teil	Neun kalibrierte Stellungen, Folge 1-2-5. Nicht kalibriert stufenlos einstellbar 1 : $\geqslant 2{,}5$
1.2.2.3. Fehlergrenze	±3 %	
1.2.2.4. Hochstzulässige Eingangsspannung	±400 V	Gleichspannung + Spitzenwert einer Wechselspannung. Bis zur 20 mV Stellung des Eingangsabschwächers Minderung bei Frequenzen über 500 kHz. Siehe Abbildung 1.2.
1.2.2.5. Instabilität des Leuchtflecks		
Gleichspannungsdrift	$< 0{,}3$ Teil pro Stunde	Bei 20 °C im Position 5 mV/Teil
Temperatur Drift	60 μV/°V	Typischer Wert

Benennung	Beschreibung	Nähere Angaben
1.2.2.6. Maximale Ablenkung		
Unverzerrt	24 Teile ⩾ 6 Teile	Für seinesförmige Wellen bis 15 MHz Für seinesförmige Wellen bis 50 MHz
Verschiebungbereich	16 Teile	8 Teile über und unter mittleren Rasterlinie.
1.2.2.7. Eingangsimpedanz	1 MOhm//15 pF	
1.2.2.8. Zeitkonstante der Eingangsschaltung	ca. 22 ms	Kopplungsschalter auf AC
1.2.2.9. Sichtbare Signalverzögerung	ca. 20 ns	
1.2.2.10. Darstellungsmöglichkeiten	nur Kanal +A nur Kanal +B oder −B Kanäle A und ±B zerhackt Kanäle A und ±B abwechselnd Kanäle A und ±B addiert	
1.2.2.11. Chopperfrequenz	≈ 1 MHz	
1.2.2.12. Übersprechen zwischen Kanälen	1:500	2 Teile Signalamplitude bei 50 MHz auf einem Kanal, eingestellt auf 0.2 V/Teil. Übersprechen wird gemessen am anderen Kanal, eingestellt auf 20 mV/Teil.
1.2.2.13. Gleichtaktunterdrückung	100 bei 1 MHz	Gemessen mit +A und −B addiert; Max. Gleichtaktsignal 8 Teile
1.2.3. HORIZONTALE ODER X ACHSE		
1.2.3.1. Darstellungsweisen	– Hauptzeitablenkung – Hauptzeitablenkung aufgehellt durch verzögerte Zeitablenkung – Verzögerte Zeitablenkung – XY-Betrieb	X Ablenkung durch: – Kanal A Signal – Kanal B Signal – Signal über EXT Anschluss der Hauptzeitablenkung – Netzfrequenz
1.2.4. HAUPTZEITABLENKUNG		
1.2.4.1. Betriebsart	Getriggert Automatisch Einmalig	Automatischer Freilauf bei Abwesenheit von Triggersignalen möglich
1.2.4.2. Zeitmassstäbe	0,5 s/Teil ... 50 ns/Teil	In 22 Kalibrierten Stufen, Folge 1-2-5. Dazwischen stufenlos einstellbar 1 : ⩾ 2,5 nicht kalibriert
1.2.4.3. Fehlergrenze des Zeitmassstabes	±3 %	+ 5 °C ... +40 °C Zeitablenkungs-Genauigkeit ±5 % für Positionen 0,5 und 0,2 s/Teil und für 0,1 und 0,05 µs/Teil

Benennung	Beschreibung	Nähere Angaben
1.2.4.4. Anzeigendehnung		
Dehnung	5 x	Geschaltet, kalibriert
Zusätzliche Abweichung	±2 %	
Kürzester Zeitmassstab	10 ns/Teil	
1.2.5. VERZÖGERTE ZEITABLENKUNG		
1.2.5.1. Betriebsart	Verzögerte Zeitablenkung startet nach Wahl, entweder sofort nach Ablauf der Verzögerungszeit oder nach Empfang des ersten Triggerimpulses nach Verstreichen der Verzögerungszeit	
1.2.5.2. Zeitmassstäbe	1 ms/Teil ... 50 ns/Teil	In 14 kalibrierten Stufen (Folge 1-2-5). Dazwischen stufenlos einstellbar 1 : ⩾ 2,5 nicht kalibriert.
1.2.5.3. Fehlergrenze des Zeitmassstabes	±3 %	+ 5 °C ... +40 °C Zeitablenkungs-Genauigkeit 5 % für Position .1 und .05 ns/Teil.
1.2.5.4. Verzögerungszeit	Stufenlos zwischen 0x und 10x der Zeitkoeffizient, der Hauptzeitablenkung	
1.2.5.5. Verzögerungszeitjitter	< 1:20.000	
1.2.6. X ABLENKUNG		
X Ablenkung über Y_A oder Y_B		
1.2.6.1. Ablenkkoeffizient	5 mV/Teil ... 2 V/Teil	Nicht kalibriert stufenlos einstellbar 1: ⩾2.5
1.2.6.2. Koeffizientabweichung	±10 %	
1.2.6.3. Bandbreite	0 ... 1 MHz	–3 dB Bandbreite über 8 Teile
1.2.6.4. Eingangsimpedanz	1 MOhm//15 pF	
1.2.6.5. Phasenverschiebung	⩽ 3° bei 100 kHz	
Externe X Ablenkung über Buchse EXT		
1.2.6.6. Ablenkkoeffizient	⩽ 450 mV/Teil	Typischer Wert 300 mV/Teil
1.2.6.7. Bandbreite	0 ... 1 MHz	–3 dB Bandbreite über 8 Teile
1.2.6.8. Eingangscharakteristiken	Gleiche Werte wie Y Kanäle	
1.2.6.9. Phasenverschiebung	⩽ 3° bei 100 kHz	

Benennung	Beschreibung	Nähere Angaben
X Ablenkung mit interner Spannung bei Netzfrequenz		
Die Ablenkung ist von der Netzspannung abhängig und ist bei Lieferung auf 8 Teile bei einer Netzspannung von 220 V eingestellt.		
1.2.7. TRIGGERUNG DER HAUPTZEITABLENKUNG		
1.2.7.1. Triggerquelle	Intern von Kanal A Intern von Kanal B Intern von Netz Extern	
1.2.7.2. Betriebsart	Automatische Triggerung	Automatischer Freilauf des Zeitablenkgenerators etwa 100 ms nach Verschwinden des Triggersignals.
	Normale Triggerung Einmaliger Ablauf der Zeitablenkung	
1.2.7.3. Triggerflanke	+ oder –	
1.2.7.4. Triggerempfindlichkeit	Intern ⩽ 0,5 Teil Extern ⩽ 150 mV	Typischer Wert 1/3 Teil Typischer Wert 100 mV
1.2.7.5. Filterbandbreite	DC 0 - 50 MHz	Typischer Wert –15 dB Bandbreite
	LF: 0 - 50 kHz LF: 10 Hz - 50 kHz HF: 30 kHz - maximum	–3 dB, Intern –3 dB, Extern –3 dB, Intern und Extern
1.2.7.6. Pegelbereich	⩾ 16 Teile ⩾ 4,8 V	Typischer Wert 24 Teile Typischer Wert 7,2 V
1.2.7.7. Eingangscharakteristiken	gleicher Wert wie Y-Kanäle	
1.2.8. TRIGGERUNG DER VERZÖGERTEN ZEITABLENKUNG		
1.2.8.1. Triggerquelle	Intern von Kanal A Intern von Kanal B Extern	
Übrige Eigenschaften sind die gleichen wie bei TRIGGERUNG DER HAUPTZEITABLENKUNG		
1.2.9. KALIBRIERUNGSEINHEIT		
1.2.9.1. Ausgangsspannung	3 V_{ss}	
1.2.9.2. Ausgangsstrom	6 mA	
1.2.9.3. Fehlergrenze	±1 %	Spannung und Strom
1.2.9.4. Frequenz	2 kHz ± 2 %	
1.2.9.5. Sicherung	Der Ausgang ist gegen Dauerkurzschlüsse gesichert	
1.2.10. STROMVERSORGUNG		
1.2.10.1. Netzspannungen	Jede Spannung zwischen 100 und 240 V ± 10 % in einem Bereich (Wechselspannung)	Jede Spannung zwischen 90 und 200 V Gleichspannung.
1.2.10.2. Netzfrequenz	46-440 Hz	
1.2.10.3. Leistungsbedarf	23 W	

Benennung	Beschreibung	Nähere Angaben

1.2.11. UMGEBUNGSEIGENSCHAFTEN

Die Umgebungsdaten gelten nur, wenn das Gerät gemäss dem offiziellen Prüfverfahren kontrolliert wird. Einzelheiten betreffend diese Verfahren sowie Funktionsstörungs-Kriterien sind auf Anfrage bei der PHILIPS-Organisation Ihres Landes oder bei N.V. PHILIPS' GLOEILAMPENFABRIEKEN, ABTEILUNG TEST- UND MESSGERATE, EINDHOVEN, HOLLAND erhältlich.

1.2.11.1. Umgebungstemperaturen	+5 °C...+40 °C	Betrieb innerhalb Spezifikation
	−10 °C...+55 °C	Arbeitsbereich
	−40 °C...+70 °C	Lagerung und Transport
1.2.11.2. Höhe	5000 m	Betriebsfähig
	15000 m	nicht Betriebsfähig
1.2.11.3. Feuchtigkeit	Das Gerät entspricht den Anforderungen gemäss IEC 68 Db Standard	
1.2.11.4. Stossfestigkeit	1000 Stösse von 10 g, ½ Sinus, Dauer 6 ms, in jeder 3 Richtungen	
1.2.11.5. Vibration	30 Minuten in jeder der drei Richtungen, 10-150 Hz; 0,7 mm (Spitze-Spitze) und 5 g maximale Beschleunigung.	
1.2.11.16. Akklimationszeit	30 Minuten für Normalbetrieb	Kommend von −10 °C nach +20 °C bei 60 % relativer Feuchtigkeit
1.2.11.17. Störgrad	Das Gerät entspricht den Anforderungen gemäss VDE Störgrad K.	

1.2.12. MECHANISCHE DATEN

1.2.12.1. Abmessung	Länge 410 mm	Ohne Bedienungsorgane, Deckel und Füsse
	Breite 316 mm	
	Höhe 154 mm	
1.2.12.2. Gewicht	8,4 kg	

1.2.13. ZUBEHÖR

1.2.13.1. Standardzubehör

Kontrastfilterscheibe
Abdeckhaube mit Aufbewahrungsraum
Faltbarer Lichtschutztubus PM 9366
BNC Uberganssstecker PM 9051
CAL Anschlussklemme - BNC Adapter
Anleitung

1.2.13.2. Wahlzubehör

PM 9335	Passiver 1:1 Messkopf
PM 9350	Passiver 10:1 Messkopf
PM 9347*)	Aktiver T.V. Messkopf
PM 9353*)	Aktiver FET-Messkopf
PM 8960	Anpassung für Gestelleneinbau
PM 8971	Kamera Flansch
PM 8980	Lange Einschaurohr
PM 9380	Oszillografenkamera
M3 ... M5	Serie Oszillografenkameras Steinheil Oszillophot

*) Falls diese Messköpfe benutzt werden sollen muss zusätzlich die Stromversorgung PM 9346 eingesetzt werden.

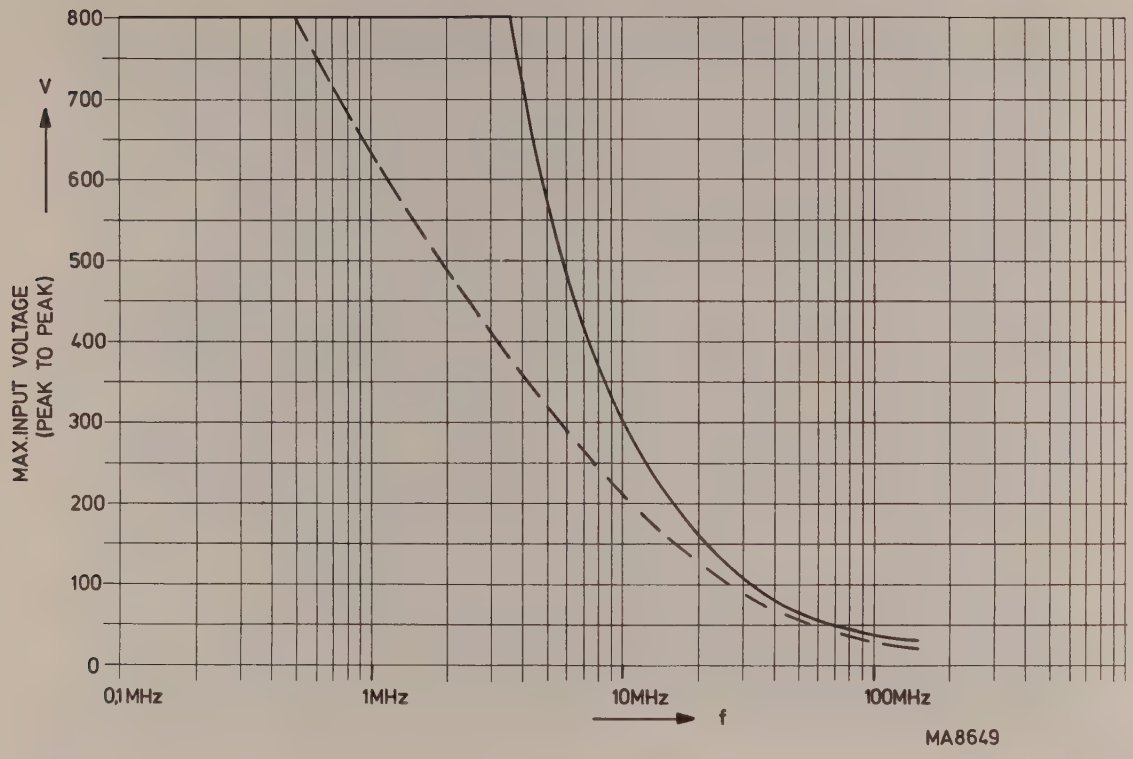


Abb. 1.2. Minderung der höchstzulässigen Eingangsspannung

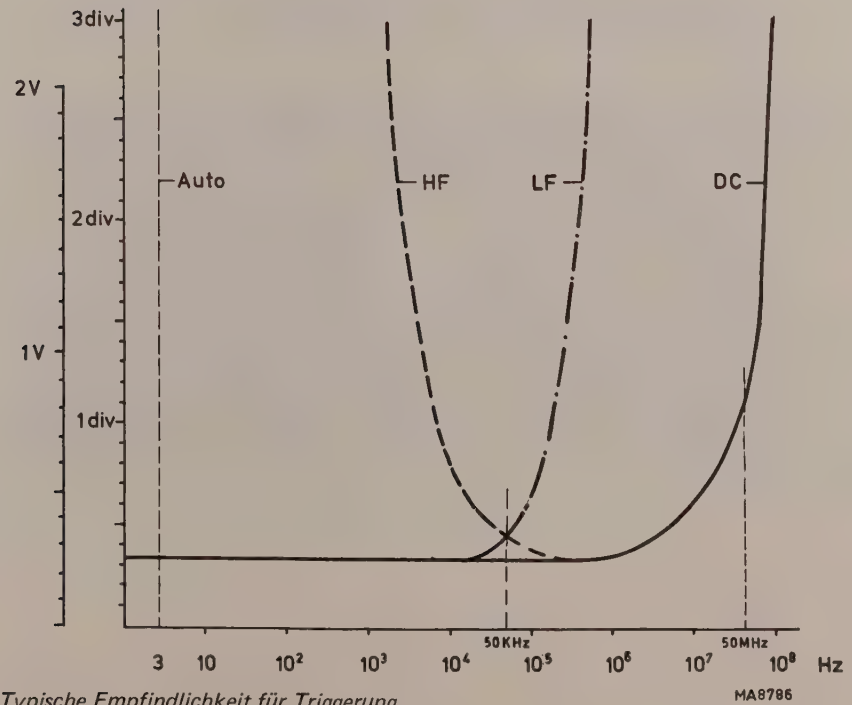


Abb. 1.3. Typische Empfindlichkeit für Triggerung

Abb. 2.1. Abnehmen der Abdeckhaube

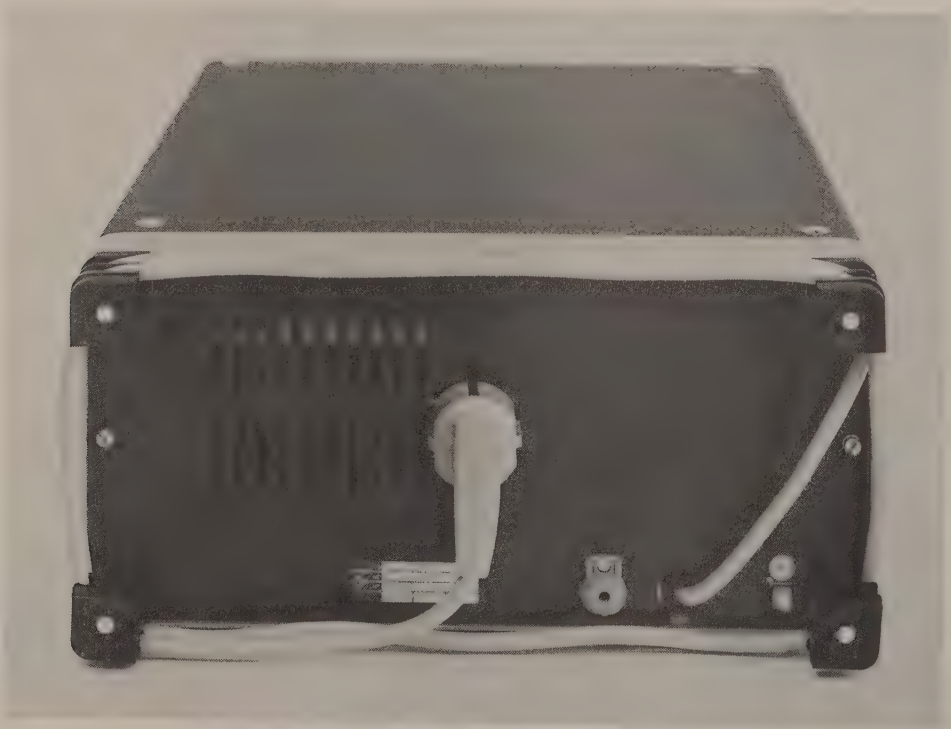


Abb. 2.2. Rückansicht des Gerätes

2. Gebrauchsanweisung

2.1. INBETRIEBNAHME

2.1.1. Abnehmen und Aufsetzen der Abdeckhaube

Abnehmen: – Den Knopf in der Mitte des Deckels eine viertal Umdrehung nach links drehen (Stellung UNLOCKED)
– Deckel abnehmen.

Aufsetzen: – Den Verriegelungsknopf in Stellung UNLOCKED drehen.
– Deckel an der Vorderseite des Oszillografen befestigen.
– Knopf eindrücken und eine viertel Umdrehung nach rechts drehen (Stellung LOCKED).

Bemerkung: Der Handgriff lässt sich drehen wenn die Druckknöpfe auf ihren Lagern eingedrückt werden.

Warnung: In diesem Gerät werden hohe Spannungen erzeugt, deshalb darf es niemals in geöffnetem Zustand eingeschaltet werden.
Vor Wartungsarbeiten ist der Netzstecker zu ziehen und ist darauf zu achten dass alle Hochspannung führenden Teile entladen sind.

2.1.2. Netzspannungseinstellungen und Sicherung

Da das Gerät bei jeder Netzspannung zwischen 90 und 264 V betriebsfähig ist, erübrigt sich das Umschalten auf die örtliche Netzspannung.
Der Sicherungshalter an der Rückwand enthält eine Sicherung von 1,6 A, träge. Die Verwendung reparierter Sicherungen und das Kurzschliessen des Sicherunghalters sind verboten.

2.1.3. Erdung

Aus Sicherheitsgründen muss der Oszillograf entweder über den Erdanschluss an der Rückseite (gekennzeichnet ⏚), oder über das Netzkabel, vorausgesetzt das Gerät wird an eine Schukosteckdose angeschlossen, geerdet werden.
Es ist zu beachten dass die Erdverbindung des Oszillografen nicht durch ein Verlängerungskabel oder irgendeine andere Vorrichtung unterbrochen wird, die keinen Erdleiter besitzt.

2.1.4. Einschalten

Der Schalter POWER ist gekoppelt mit der Rasterbeleuchtungseinsteller ILLUM und befindet sich an der Vorderseite des Gerätes unter dem Bildröhrenrahmen.
Der Oszillograf darf niemals eingeschaltet werden, wenn eine Leiterplatte oder Baustein entfernt wurde.
Eine Leiterplatte oder Baustein darf nicht früher als eine Minute nach Ausschaltung des Gerätes entfernt werden.

2.2. BEDIENUNGSANLEITUNG

Vor dem Einschalten ist zu kontrollieren, ob der Oszillograf gemäss Abschnitt 2.1. "INBETRIEBNAHME" angeschlossen ist, und ob die dort erwähnten Vorsorgemassnahmen beachtet wurden.

2.2.1. **Bedienungsorgane und Buchsen** (Abb. 2.3.)

2.2.1.1. Vertikalkanäle

A/ALT/CHOP/ADD/B	Einstellung der Darstellungsarten, Drucktastenschalter mit 5 Stellungen.
A eingedrückt	Vertikalablenkung durch Signal von Kanal A.
ALT eingedrückt	Das Bild wird am Ende (jeder Periode) des Zeitablenksignales von einem Vertikalkanal auf den anderen umgeschaltet.
CHOP eingedrückt	Das Bild wird mit einer Festfrequenz von einem Kanal auf den anderen umgeschaltet.
ADD eingedrückt	Vertikalablenkung durch die Summe der Signale von Kanal A und B.
B eingedrückt	Vertikalablenkung durch Signal von Kanal B. Wird keine Taste eingedrückt ist die Betriebsweise des Gerätes wie bei Einstellung A oder B eingedrückt.
POSITION	Stufenlose Einstellung der vertikalen Lage des Bildes.
PULL TO INVERT B	Zug-Druck Schalter zur Umkehrung der Signalpolarität Kanal B.
AMPL	Stufenweise Einstellung der Vertikalablenkkoeffizienten. Wahlschalter mit 9 Stellungen.
AMPL/CAL (blau)	Stufenlose Einstellung der Vertikalablenkkoeffizienten. In Stellung CAL ist der Ablenkkoeffizient kalibriert.
BAL (Schraubenziehereinstellung)	Stufenlose Einstellung des Gleichspannungsgleichgewichtes des Vertikalverstärkers.
GAIN (Schraubenziehereinstellung)	Stufenlose Einstellung der Gesamtverstärkung der Vertikalkanäle.
AC/0/DC	Signalkopplung, Drucktastenschalter mit 3 Stellungen.
AC eingedrückt	Kopplung über einen Sperrkondensator.
0 eingedrückt	Verbindung zwischen Eingangsschaltung und Eingangsbuchse wird unterbrochen und der Verstärkereingang geerdet.
DC eingedrückt	Direkte Kopplung Ist keine Taste eingedrückt so gilt Einstellung AC.
A 1 MOhm - 15 pF	BNC Eingangsbuchse für Kanal A
B 1 MOhm - 15 pF	BNC Eingangsbuchse für Kanal B

2.2.1.2. Horizontaler Kanal

DEL'D TB - EXT. X DEFL. - MAIN TB	Einstellung der Horizontalablenkung, Drucktastenschalter mit 3 Stellungen.
DEL'D TB eingedrückt	Die Horizontalablenkspannung wird vom verzögerten Zeitablenkgenerator geliefert.
EXT. X DEFL eingedrückt	Horizontalablenkung durch das Signal von Kanal A, das Signal von Kanal B oder durch ein Netzfrequenzsignal.
MAIN TB eingedrückt	Horizontalablenkspannung wird vom Hauptzeitablenkgenerator geliefert; ein Teil der Darstellung wird aufgehellt (Ausgenommen in Stellung OFF des TIME/DIV Schalters des verzögerten Zeitablenkgenerators). Ist keine Taste eingedrückt so gilt Einstellung MAIN TB.

POSITION TB MAGN	Stufenlose Einstellung der horizontalen Lage des Bildes; gekoppelt mit einem Zug-Druck-Schalter der den Horizontalablenkkoeffizienten 5 mal steigert.

2.2.1.3. Hauptzeitablenkgenerator

LEVEL SLOPE	Stufenlose Einstellung des Triggersignalpegels bei welchem der Zeitablenkgenerator startet. Diese Einstellung ist gekoppelt mit einem Zug-Druck-Schalter zur Triggerungswahl auf der positiv oder negativ gerichteten Flanke des Triggersignales.
NOT TRIG'D	Signallampe leuchtet auf bei Wartestellung des Zeitablenkgenerators.
AUTO - TRIG - SINGLE	Triggerart-Einstellungen; Drucktastenschalter mit 3 Stellungen.
AUTO eingedrückt	Liegt kein Triggersignal an so läuft der Hauptzeitablenker frei.
TRIG eingedrückt	Der Zeitablenkgenerator wird auf normale Weise getriggert.
SINGLE eingedrückt	Nach Betätigung der Taste SINGLE, läuft der Zeitablenkgenerator nach Empfang eines Triggersignals nur einmal ab.

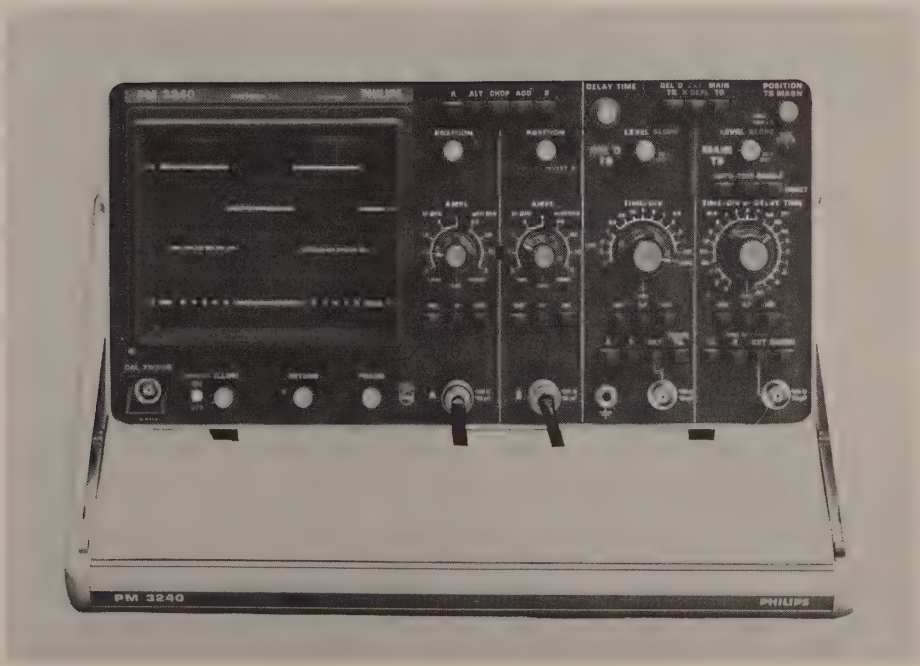


Abb. 2.3. Vorderansicht des Gerätes

TIME/DIV or DELAY TIME	Einstellung des Zeitkoeffizienten der Hauptzeitablenkung; Drehschalter mit 22 Stellungen.
TIME/DIV-CAL (blau)	Stufenlose Einstellung des Zeitkoeffizienten der Hauptzeitablenkung. In Stellung CAL ist der Zeitkoeffizient kalibriert.
DC-LF-HF	Triggerkopplung; Drucktastenschalter mit 3 Stellungen.
DC	Triggersignale direkt gekoppelt.
LF	Kopplung über Tiefpass für Frequenzen bis 50 kHz (für externe Triggerung über einen Bandfilter von 10 Hz bis 50 kHz).
HF	Kopplung über Hochpass für Frequenzen über 50 kHz. Ist keine Taste eingedrückt so gilt Einstellung DC.
TRIG oder X DEFL	Wähler für Triggerquelle oder externe X Ablenkung. Drucktastenschalter mit 4 Stellungen.
A	Internes Trigger- oder X-Ablenksignal von Kanal A.
B	Internes Trigger- oder X-Ablenksignal von Kanal B.
EXT	Triggerung auf externes Signal über angrenzende 1 MOhm - 15 pF Buchse. Durch eindrücken der Taste EXT X-DEFL der Horizontalablenkungs-Einstellung wird diese Buchse mit dem Eingang des Horizontalverstärkers verbunden.
MAINS	Triggerung- oder X-Ablenkungssignal von einer internen Spannung mit der Netzfrequenz. Ist keine Taste eingedrückt so gilt Einstellung A.
1 MOhm - 15 pF	BNC Buchse für externe Triggerung oder Horizontalablenkung.

2.2.1.4. Verzögerter Zeitablenkgenerator

DELAY TIME	Stufenlose Einstellung der Verzögerungszeit, wirkt zusammen mit der TIME/DIV Einstellung des Hauptzeitablenkgenerators.
LEVEL SLOPE	Stufenlose Einstellung zur Pegelwahl des Triggerungsignals, bei welchem der verzögerte Zeitablenkgenerator startet. Diese Einstellung ist gekoppelt an einen Zug-Druck-Schalter zur Triggerungswahl auf der positiv oder negativ gerichteten Flanke des Triggersignals.
TIME/DIV	Einstellung des Zeitkoeffizienten der verzögerten Zeitablenkung. Drehschalter mit 15 Stellungen. In Stellung OFF wird die verzögerte Zeitablenkung abgeschaltet.
TIME/DIV - CAL (blau)	Stufenlose Einstellung des Zeitkoeffizienten der verzögerten Zeitablenkung. In Stellung CAL ist der Zeitkoeffizient kalibriert.
DC - LF - HF	Triggerkopplung; Drucktastenschalter mit 3 Stellungen.
DC	Triggersignale direkt gekoppelt.
LF	Kopplung über Tiefpass für Frequenzen bis 50 kHz (für externe Triggerung über einen Bandfilter von 10 Hz bis 50 kHz).
HF	Kopplung über Hochpass für Frequenzen über 50 kHz. Ist keine Taste eingedrückt so gilt Einstellung DC.

A - B - EXT - MAIN TB	Triggerquellen Einstellungen; Drucktastenschalter mit 4 Stellungen
A	Internes Triggerungssignal von Kanal A.
B	Internes Triggerungssignal von Kanal B.
EXT	Triggerung auf ein externes Signal über angrenzende 1 MOhm - 15 pF Buchse. Ist keine Taste eingedrückt so gilt Einstellung A.
MAIN TB	Verzögerte Zeitablenkung startet gleich nach Ablauf der Verzögerungszeit.
1 MOhm - 15 pF	BNC Eingangsbuchse für externes Triggersignal.

2.2.1.5. Elektronenstrahlröhre

ILLUM POWER	Stufenlose Einstellung der Rasterbeleuchtung; zugleich Netzschalter. Signallampe zeigt Betriebszustand (ON) an.
INTENS	Stufenlose Einstellung der Helligkeit des Bildes.
FOCUS	Stufenlose Einstellung zur Fokussierung des Elektronenstrahls.

2.2.1.6. Verschiedenes

CAL	Ausgangsbuchse an der eine Rechteckspannung von 3 V_{ss} und ein Strom von 6 mA mit einer Frequenz von 2 kHz zur Verfügung steht. Amplituden-Genauigkeit: ±1 %. Frequenz-Genauigkeit: ±2 %. Der Ausgang ist gegen Dauerkurzschlüsse gesichert.
⏚	Messerde

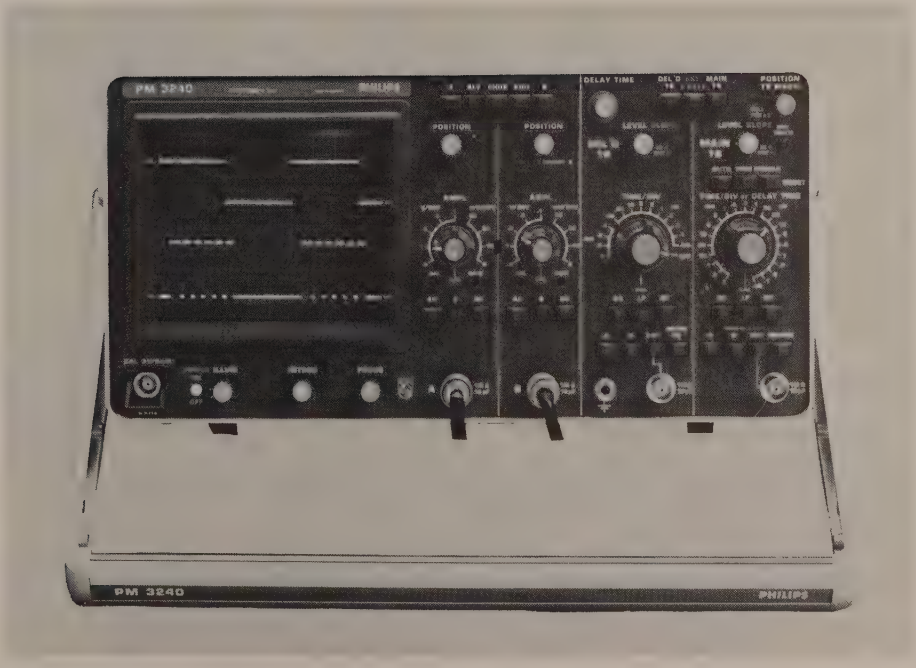


Abb. 2.3. Vorderansicht des Gerätes

2.2.2. Vorbereitende Einstellungen

Da die folgenden Einstellungen für beide vertikale Kanäle gleich sind, ist nur die Vorschrift für Kanal A gegeben.

2.2.2.1. Einstellen Gleichspannungsgleichgewicht

- Drucktaste A des Darstellungsartenschalters betätigen.
- Drucktaste AUTO des Triggerartenschalters betätigen.
- Drucktaste MAIN TB des Horizontalablenkungsschalters betätigen.
- Schalter AMPL in Stellung 5 mV und stufenlosen Einsteller in Stellung CAL bringen.
- Bild mit Einsteller POSITION zentrieren.
- Mit Einstellern INTENS und FOCUS die Schärfe des Bildes regeln.
  Nicht erwähnte Einstellungen dürfen in jeder beliebigen Stellung stehen.
- Es ist darauf zu achten dass das Bild nicht springt, wenn der Schalter zwischen der 5- und 10 mV-Stellung betätigt wird.
  Nötigenfalls Einstellung BAL an der Vorderseite unter dem Schalter AMPL erneut einstellen.

2.2.2.2. Verstärkungseinstellung

Falls nicht anders angegeben sind die Bedienungsorgane in den selben Stellungen wie in vorgehender Einstellvorschrift.

- Schalter AC-0-DC in Stellung DC.
- Schalter AMPL in Stellung .5 V und stufenlosen Einsteller in Stellung CAL.
- Buchse CAL mit Eingangsbuchse A verbinden.
- Prüfen ob die Bildhöhe 6 Teile beträgt.
  Nötigenfalls Einstellung GAIN unter dem Schalter AMP neu einstellen.

2.2.3. Eingänge A und B und ihre Möglichkeiten

Der Oszillograf besitzt zwei identische Kanäle, die entweder zusammen mit einem oder beiden Zeitablenkgeneratoren für YT Messungen, oder aber zusammen mit dem externen Horizontalkanal für XY Messungen verwendet werden können.

2.2.3.1. YT-Messungen

Zur Darstellung eines Signals ist einer der beiden Vertikalkanäle mit Taste A oder Taste B der Darstellungsartenschalter zu wählen.
Wird Taste ALT oder CHOP gedrückt, können zwei verschiedene Signale gleichzeitig abgebildet werden. Der Y-Ablenkkoeffizient und die Polarität können für jeden Kanal getrennt gewählt werden. Wird Taste ALT betätigt wird die Darstellung beim Rücklauf des Zeitablenksignals von einem Kanal auf den anderen umgeschaltet. Obwohl Stellung ALT für alle Ablenkzeiten verwendet werden kann, ergibt für lange Ablenkzeiten Stellung CHOPPED eine bessere Bildgüte, da das abwechselnde Darstellen der beiden Eingangssignale während dieser langen Ablenkzeiten deutlicher sichtbar ist.

In Stellung CHOPPED, wird die Darstellung mit einer Festfrequenz von einem Kanal auf den anderen umgeschaltet.
In Stellung ADDED des Darstellungsartenschalters werden die Signalspannungen der beiden vertikalen Kanäle addiert. Abhängig von der Stellung der Polaritätsschalter von Kanal B wird entweder die Summe oder die Differenz der Eingangssignale dargestellt.

2.2.3.2. XY-Messungen

Wenn Drucktaste EXT X DEFL des Horizontalablenkungsschalters und Taste A des TRIG OR X DEFL-Schalters eingedrückt sind ist der Zeitablenkgenerator ausgeschaltet. Ein Signal das über Kanal A zugeführt wird kann nur zur Horizontalablenkung verwendet werden. Der Schalter AC/0/DC und der Stufenabschwächer von Kanal A bleiben wirksam.
Einsteller X DEFL/HOLD OFF ermöglicht stufenlose Einstellung der Ablenkungskoeffizienten, für horizontale Verschiebung des Bildes wird Einsteller X POSITION verwendet.

Für X Ablenkung kann auch der vertikale Kanal B verwendet werden.
In diesem Fall Taste B des TRIG OR X DEFL-Schalters eindrücken.

Es ist ferner möglich eine interne Spannung der Netzfrequenz, oder ein Signal angelegt an die EXT Buchse (Vorderseite rechts unten), für die X-Ablenkung zu verwenden. Zu diesem Zweck die betreffende Drucktaste des TRIG OR X DEFL-Schalters eindrücken.

2.2.3.2. AC/0/DC Schalter

Die zu beobachtenden Signale sind an die Buchse (n) A und/oder B zu legen und der AC/0/DC Schalter abhängig von der Zusammensetzung der Signale auf AC oder DC zu stellen. Da der vertikale Verstärker gleichspannungsgekoppelt ist, ist die ganze Bandbreite des Gerätes verfügbar und die Gleichspannungskomponenten werden in Stellung DC des AC/0/DC-Schalters als Bildverschiebungen sichtbar.
Sind kleine Signale hohen Gleichspannungen überlagert kann dies störend sein. Jede Abschwächung des Signals verursacht auch eine Abschwächung der kleinen Wechselspannungskomponenten. In diesem Falle ist der Eingangsschalter in AC Stellung zu bringen wodurch ein Sperrkondensator die Gleichspannungs- und Niederfrequenz-Signale unterdrückt. Dies hat Dachschräge zur Folge bei Darstellungen von Niederfrequenzsignalen.
Stellung 0 unterbricht das Signal und erdet den Verstärkereingang um den 0 V Pegel schnell bestimmen zu können.

2.2.4. Triggerung

Wenn ein Signal dargestellt werden soll, muss, um ein stillstehendes Bild zu erhalten, die Horizontalablenkung stets an einem festen Punkt des Signals gestartet werden.
Der Zeitablenkgenerator wird folglich von in der Triggereinheit erzeugten schmalen Triggerimpulsen gestartet und durch ein Signal gesteuert das entweder den vertikalen Eingangssignalen, einer internen Netzfrequenzspannung oder einer externen Quelle entstammen kann.

2.2.4.1. Triggerkopplung

Mit Schalter DC/LF/HF kann man drei verschiedene Triggerkopplungsarten wählen. In den Stellungen HF und LF ist die Übertragungscharakteristik begrenzt.
In Stellung DC wird das Triggersignal unverändert durchgelassen.
In Stellung LF wird ein 0 Hz (10 Hz bei externer Triggerung) bis 50 kHz Bandpass eingesetzt. Diese Stellung dient zur Verminderung von Störungen durch Rauschen.
In Stellung HF wird ein 50 kHz Hochpass eingesetzt. Diese Stellung kann zum Herabsetzen von Störungen durch Brummen verwendet werden.

2.2.4.2. Selektieren der Triggerquelle und Einstellen des Triggerpegels

Das Triggersignal kann von Kanal A (Taste A gedrückt), von Kanal B (Taste B gedrückt), von einer externen Quelle (Taste EXT gedrückt) oder einer internen Spannung mit Netzspannung (Taste MAINS gedrückt) entnommen werden.
Der Triggerimpulsformer ist ein zweifach gesteuerter Multivibrator, der von den Ausgangssignalen eines Differenzverstärkers gesteuert wird.
Das Triggersignal, das nicht vom stufenlosen Einsteller AMPL beeinflusst wird, wird zusammen mit Gleichspannungen die mittels Potentiometer LEVEL einstellbar sind, den Eingängen des Differenzverstärkers zugeführt.
Abhängig von der LEVEL Einstellung wird ein bestimmter Teil des Triggersignals durch den Differenzverstärker verstärkt.
Der Multivibrator ist somit auf einen fasten Punkt des Triggersignals geschaltet (Abb. 2.4.). Das bedeutet, dass es mit Hilfe des Einstellers LEVEL möglich ist die Form des Triggersignals abzutasten (bei interner Triggerung A oder B gleich der Form des darzustellenden Signals) und somit den Punkt zu wählen, an dem der Multivibrator umgeschaltet wird.
Der Potentiometer ist mit einem Zug-Druck-Schalter versehen, der die Wahl der Triggerflanke erlaubt.

2.2.4.3. Automatische Triggerung

Wenn Taste AUT des AUTO-TRIG-SINGLE-Schalters gedrückt ist - und wenn keine Triggerimpulse vorhanden sind - ist der Zeitablenkgenerator automatisch freilaufend. Das Bild ist daher stets sichtbar. Die Stellung AUTO kann in allen Fällen verwendet werden in welchen auch Stellung TRIG anwendbar ist, ausgenommen bei Signalfrequenzen niedriger als 10 Hz oder Impulsreihen mit einer "AUS"-Zeit über 100 ms.
Sobald Triggerimpulse vorhanden sind, wird der Freilauf des Zeitablenkgenerators automatisch beendet und der Zeitablenkgenerator erneut getriggert wie erwähnt in Abschnitt 2.2.4.1. und 2.2.4.2.
Wird Taste TRIG oder Taste SINGLE eingedrückt ist die Automatik ausgeschaltet.

2.2.4.4. SINGLE-SWEEP-Triggerung

Wenn einmalige Vorgänge beobachtet (und in der Regel fotografiert) werden müssen, ist es oft wünschenswert dafür zu sorgen, dass nur ein Sägezahn erzeugt wird, selbst wenn möglicherweise nach Darstellung dieses Vorgangs mehrere Triggerimpulse erzeugt würden. Zu diesem Zweck Taste SINGLE eindrücken. Der erste Triggerimpuls, der nach Loslassen der gedrückten Taste erscheint, startet den Zeitablenkgenerator.
Der Zeitablenkgenerator wird dann blockiert bis Taste SINGLE wieder betätigt wird. Die Lampe NOT TRIG'D leuchtet auf sobald Taste SINGLE losgelassen wird und erlischt erst wenn der Sägezahn beendet ist.

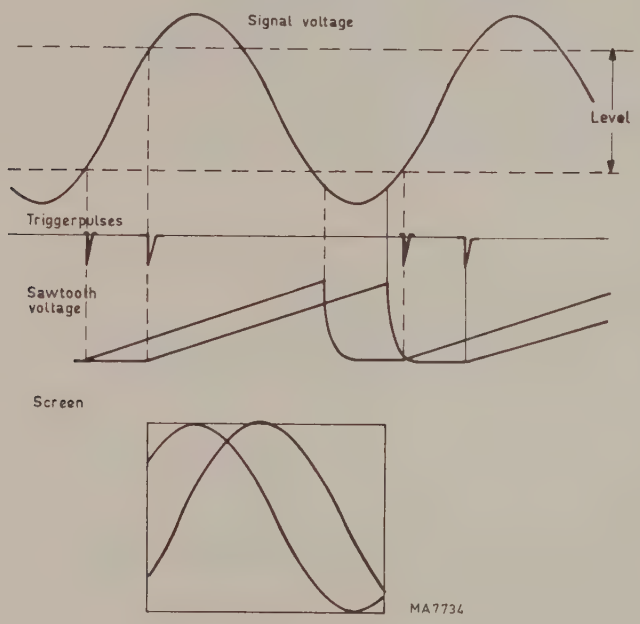


Abb. 2.4. Abtasten der Wellenform mittels des LEVEL Potentiometers

2.2.5. Dehnung der Zeitablenkung

Die Dehnung der Zeitablenkung wird mit einem Zug-Druck-Schalter TB MAGN der an den Einsteller für horizontale POSITION gekoppelt ist, eingestellt. Wenn dieser Schalter in Stellung x5 gezogen ist wird ein 5 mal schnellerer Zeitmassstab des Hauptzeitablenkgenerators eingestellt. Folglich wird der Signalteil, welcher in der x1 Stellung (TB MAGN eingedrückt) über eine Breite von ein Teil (DIV) in der Schirmmitte dargestellt wird, in der x5 Stellung über die Gesamtbreite des Schirmes geschrieben.
Jeder Teil des Bildes kann mit dem horizontalen POSITION Einsteller zur genauen Beobachtung sichtbar gemacht werden.
In der x5 Stellung wird der Zeitkoeffizient durch Teilen des gegebenen Wertes TIME/DIV. durch 5 ermittelt.

2.2.6. Gebrauch der verzögerten Zeitablenkung

Die verzögerte Zeitablenkung kann zur genauen Beobachtung komplexer Signale verwendet werden. Wenn die Drucktaste MAIN TB der Triggerquellenschalter nach Einschalten des verzögerten Zeitablenkung (dass heisst TIME/DIV Schalter nicht in Stellung OFF) eingedrückt wird, wird sofort ein Teil des dargestellten Signals in Stellung MAIN TB des Horizontalablenkungs-Schalters zusätzlich aufgehellt. Mit dem DELAY TIME Einsteller ist dieser zusätzlich aufgehellte Teile über die Zeitachse verschiebbar. Die Zeitdauer dieses zusätzlich aufgehellten Teils ist mit den Einstellern TIME/DIV des verzögerten Zeitablenkgenerators sowohl stufenweise wie stufenlos einstellbar. Mit Drucktaste DEL'D TB des Horizontalablenkungs-Schalters wird der zusätzlich aufgehellte Teil über die gesamte Schirmbreite sichtbar gemacht. In Stellung DEL'D TB, wird die Verzögerungszeit (dass heisst die Zeit zwischen dem Startpunkt der Hauptzeitablenkung und dem Startpunkt der verzögerten Zeitablenkung) bestimmt durch die Einstellungen des Schalters TIME/DIV der Hauptzeitablenkung und die des DELAY TIME Einstellers.
Falls Taste A, B oder EXT. der Triggerquellenschalter ist gedrückt startet der erste Triggerimpuls nach der gewählten Verzögerungszeit die verzögerte Zeitablenkung. Die Triggereinheit des verzögerten Zeitablenkgenerators liefert diesen Triggerimpuls. Diese Stellung kommt zur Anwendung wenn durch Jitter eine undeutliche Darstellung zu beobachten ist. Dieses Jitter kann durch das beobachtende Signal selbst oder durch externe Dehnung in den Zeitablenkschaltungen entstehen.

Notice d'emploi

1. Généralités

1.1. INTRODUCTION

L'oscilloscope portatif PM 3240 permet de mesurer des signaux de faible amplitude (5 mV/DIV) sur une gamme de fréquence étendue (50 MHz).

Il y a un large choix d'affichages possibles, tels que: l'une ou l'autre voie, deux voies alternées ou commutées, deux voies additionnées, en positions normales et inversées pour les deux signaux d'entrée, avec base de temps principale et retardée.

L'oscilloscope PM 3240 se caractérise par une alimentation à faible dissipation. Cette unité d'alimentation fonctionne pour une tension alternative comprise entre 90 V et 264 V, de sorte qu'il n'est pas nécessaire d'adapter l'appareil à la tension secteur locale.

Toutes ces caractéristiques donnent au présent oscilloscope une grande variété d'applications.

Fig. 1.1. Oscilloscope double trace portatif v.h.f. PM 3240.

1.2. CARACTERISTIQUES TECHNIQUES

Les spécifications sont valables après que l'appareil a été préchauffé pendant 15 minutes.
Les valeurs indiquées avec tolérance sont garanties. Les chiffres sans tolérance ne servent qu'à titre d'information et correspondent aux charactéristiques d'un appareil moyen.

Désignation	Spécification	Information supplémentaire
1.2.1. TUBE A RAYONS CATHODIQUES		
Type	PHILIPS D14-125 HG/08	Tube à face rectangulaire, type domed mesh, post-accélérateur, couche phosphore doublée de métal
Aire de mesure	80 mm x 100 mm	
Type d'écran	Phosphore P31 (GH)	en option, couche phosphore P11 (BE) ou P7 (GM)
Vitesse d'écriture photographique	> 750 cm/μs	Mesuré avec un appareil photographique Steinheil Oscillophot M5 Ouverture: 1:1,2 Rapport objet/image: 1:0,5 Film: Polaroid 410 (10000 ASA) Pas de pré-voilage Phosphore du type P31 (GH)
Tension d'accélération totale	10 kV	
Graticule	Interne	Illumination continuellement variable
Gravures	Divisions centimétriques avec subdivisions de 2 mm sur les axes centraux. Les lignes interrompues indiquent les points 10 % et 90 % pour la mesure du temps de montée.	
1.2.2. AXE VERTICAL OU Y		
1.2.2.1. Bande passante		
Gamme de fréquence	continu à 50 MHz 10 Hz ... 50 MHz	(–3 dB) largeur de bande en couplage continu (–3 dB) largeur de bande en couplage alternatif
Temps de montée	≈ 7 ns	Mesuré avec tension de bloque à 6 div.
Dépassement	±2 %	temps de montée 2 ns, frequenze 1 MHz
1.2.2.2. Coefficients de déviation	5 mV/DIV ... 2 V/DIV	en 9 positions étalonnées (progression 1-2-5) avec commande continue non-calibrée 1 : ⩾ 2,5 par potentiomètre
1.2.2.3. Erreur limite	±3 %	
1.2.2.4. Tension d'entrée maximale admise	±400 V	tension continue + tension alternative crête. Jusqu'à la position 20 mV de l'atténuateur d'entrée réduction de la tension d'entrée maximale admise à fréquences > 500 kHz Voir Fig. 1.2
1.2.2.5. Instabilité de la position du spot		
Dérive de trace	< 0,3 Div/h	A 20° en position 5 mV/Div.
Dérive en température	< 60 μV/°C	Valeur typique

Désignation		
1.2.2.6. Déviation maximale		
Sans distorsion	24 divisions	Pour tensions sinusoïdals jusqu'à 15 MHz
	⩾ 6 divisions	Pour tensions sinusoïdals jusqu'à 50 MHz
Gamme de décadrage	16 divisions	8 divisions vers le haut et vers la bas à partir de la ligne centrale horizontale du graticule
1.2.2.7. Impédance d'entrée	1 MOhm//15 pF	
1.2.2.8. Constant de temps RC d'entrée	environ 22 ms	Commutateur de couplage en position AC
1.2.2.9. Retard visible du signal	environ 20 ns	
1.2.2.10. Modes d'affichage	Voie A seulement Voie + ou −B seulement Voies A et ±B découpées Voies A et ±B alternées Voies A et ±B additionnées	
1.2.2.11. Fréquence de commutation	≈ 1 MHz	
1.2.2.12. Diaphonie entre voies	1 : 500	avec un signal de 2 divisions d'amplitude à 50 MHz sur une voie réglée sur 0,2 V/DIV. La diaphonie est mesurée sur l'autre voie réglée sur 20 mV/DIV
1.2.2.13. Facteur de réjection en mode commun	100 à 1 MHz	En mode +A et −B additionés; signal max. en mode commun: 8 div.
1.2.3. AXE HORIZONTAL OU X		
1.2.3.1. Modes de représentation	– Base de temps principale – Base de temps principale intensifiée par base de temps retardée – Base de temps retardée – Fonctionnement XY	Déviation X par: – le signal voie A – le signal voie B – le signal appliqué au connecteur EXT de la base de temps principale – la fréquence secteur
1.2.4. BASE DE TEMPS PRINCIPALE		
1.2.4.1. Fonctionnements	Déclenché Automatique Balayage unique	En automatique, la base de temps est en fonctionnement libre en l'absence de signaux de déclenchement
1.2.4.2. Vitesses de balayage	0,5 s/div ... 50 ns/div	en 22 positions étalonnées (progression 1-2-5) Commande continue non-étalonnée 1 : ⩾ 2,5 entre les échelons par potentiomètre
1.2.4.3. Précision de mesure	±3 %	entre +5 °C et +40 °C précision ±5 % sur les positions 0,5 et 0,2 s/div et 0,1 et 0,05 µs/div.

Désignation	Spécification	Information supplémentaire
1.2.4.4. Expansion de la vitesse de balayage		
Agrandissement	5x	commutable et étalonné
Erreur supplémentaire	±2 %	
Coefficient de temps de balayage maximum	10 ns/div.	
1.2.5. BASE DE TEMPS RETARDEE		
1.2.5.1. Fonctionnement	La base de temps retardée est déclenchée par la base de temps principale immédiatement après le temps de retard choisi ou par le signal à examiner après le temps de retard (absence de jitter)	
1.2.5.2. Vitesses de balayage	1 ms/DIV ... 50 ns/DIV	en 14 positions étalonnées (progression 1-2-5) Commande continue non-étalonnée 1 : ⩾ 2,5 entre les échelons par potentiomètre
1.2.5.3. Précision de mesure	±3 %	entre +5 °C et +40 °C précision ±5 % sur les positions 0,1 et 0,05 µs/DIV
1.2.5.4. Retard	Continuellement variable entre 0x et 10x le coefficient de temps de la base de temps principale	
1.2.5.5. Instabilité du retard	< 1 : 20 000	
1.2.6. DEVIATION X		
Déviation X par Y_A ou Y_B		
1.2.6.1. Coefficient de déviation	5 mV/DIV à 2 V/DIV	Commande continue non-étalonnée 1 : ⩾2,5
1.2.6.2. Erreur de mesure	±10 %	
1.2.6.3. Bande passante	0 ... 1 MHz	–3 dB sur 8 DIV
1.2.6.4. Impédance d'entrée	1 MOhm//15 pF	
1.2.6.5. Déphasage	⩽ 3° à 100 kHz	
Déviation externe X par douille EXT		
1.2.6.6. Coefficient de déviation	⩽ 450 mV/DIV	Valeur typique 300 mV/DIV
1.2.6.7. Bande passante	0 à 1 MHz	–3 dB sur 8 DIV
1.2.6.8. Caractéristiques d'entrée	mêmes que pour voies Y	
1.2.6.9. Déphasage	⩽ 3° à 100 kHz	

Désignation	Spécification	Information supplémentaire

Déviation X avec tension interne à la fréquence secteur

La déviation dépend de la tension secteur et est réglée à l'usine sur 8 DIV pour tension secteur 220 V.

1.2.7. DECLENCHEMENT DE LA BASE DE TEMPS PRINCIPALE

1.2.7.1. Source	Interne à partir de la voie A Interne à partir de la voie B Interne à partir du secteur Source externe	
1.2.7.2. Mode	Automatique	Fonctionnement automatique du générateur de base de temps environ 100 ms après la disparition du signal de déclenchement
	Levier manuel Balayage simple	
1.2.7.3. Polarité	+ ou −	
1.2.7.4. Sensibilité	Interne ⩽ 0,5 DIV Externe ⩽ 150 mV	Valeur typique 1/3 DIV Valeur typique 100 mV
1.2.7.5. Bande passante du filtre	DC: 0-50 MHz	Réponse uniforme, en interne et en externe; valeur typique −15 dB
	LF: 0 - 50 kHz LF: 10 Hz - 50 kHz HF: 50 kHz - maximum	−3 dB, interne −3 dB, externe −3 dB, interne et externe
1.2.7.6. Gamme de niveau		
Interne Externe	⩾ 16 DIV ⩾ 4,8 V	Valeur typique 24 DIV Valeur typique 7,2 V
1.2.7.7. Caractéristiques d'entrée	Identique aux voies Y	

1.2.8. DECLENCHEMENT DE LA BASE DE TEMPS RETARDEE

1.2.8.1. Source	Interne à partir de la voie A Interne à partir de la voie B Externe	

Les autres caractéristiques sont identiques à celles mentionnées au paragraphe 1.2.7. DECLENCHEMENT DE LA BASE DE TEMPS PRINCIPALE.

1.2.9. UNITE D'ETALONNAGE

1.2.9.1. Tension de sortie	3 V_{cc}	
1.2.9.2. Courant de sortie	6 mA	
1.2.9.3. Erreur limite	±1 %	Tension et courant
1.2.9.4. Fréquence	2 kHz ± 2 %	
1.2.9.5. Protection	La sortie est protégée contre des courts-circuits même continus.	

1.2.10. ALIMENTATION

1.2.10.1. Tensions secteur	Toute tension comprise entre 100 et 240 V ±10 % (c.a.)	Toute tension entre 90 et 200 V (c.c.)
1.2.10.2. Fréquence secteur	46 à 440 Hz	
1.2.10.3. Consommation	23 W	

Désignation	Spécification	Information supplémentaire

1.2.11. POSSIBILITES D'APPLICATION EN RAPPORT AVEC L'ENVIRONNEMENT

Les données d'environnement ne s'appliquent que lorsque l'appareil est contrôlé conformément aux processus officiels. Pour plus de détails sur ces processus et les critères de panne, s'adresser à l'organisation Philips locale ou à N.V. Philips' Gloeilampenfabrieken, Test and Measuring Department, Eindhoven, Holland.

1.2.11.1. Température ambiante	+5 °C ... +40 °C	Gamme nominale d'utilisation
	−10 °C ... +55 °C	Gamme limite de fonctionnement
	−40 °C ... +70 °C	Gamme d'emmagasinage et de transport
1.2.11.2. Altitude	5 000 m	Fonctionnement
	15 000 m	A l'arrêt
1.2.11.3. Humidité	L'appareil répond aux normes IEC 68 Db	
1.2.11.4. Choc	1000 chocs de 10 g, ½ sinusoïde, durée 6 ms, dans chacune des directions	
1.2.11.5. Vibration	30 min. dans chacune des trois directions, 10-150 Hz; 0,7 mm crête-à-crête et 5 g accélération maximale.	
1.2.11.6. Temps de rétablissement	15 minutes (en fonctionnement normal)	quand l'appareil passe de −10 °C à +20 °C à 60 % d'humidité relative
1.2.11.7. Perturbation electromagnétique	L'appareil répond aux normes VDE, Störgrad K	

1.2.12. CARACTERISTIQUES MECANIQUES

1.2.12.1. Dimensions	Longueur 410 mm	Non compris commandes, couvercle et pieds
	Largeur 316 mm	
	Hauteur 154 mm	
1.2.12.2. Poids	8,4 kg	

1.2.13. ACCESSOIRES

1.2.13.1. Accessoires livrés avec l'appareil

Filtre de contraste
Couvercle frontale avec remplacements pour accessoires
Visière pliante PM 9366
Adaptateur BNC banane PM 9051
Borne CAL - Adaptateur BNC
Notice d'emploi et d'entretien
(Notice d'emploi en Francias, Notice de service en Anglais)

1.2.13.2. Accessoires en option

PM 9335	Sonde passive 1:1
PM 9351	Sonde passive 10:1
PM 9347*)	Sonde t.v. active
PM 9353*)	Sonde F.E.T. active
PM 8960	Adaptateur pour montage en rack
PM 8971	Adaptateur de camera
PM 8980	Visière longue
PM 9380	Appareil de photographie d'oscillogrammes
M3 ... M5	Gamme d'appareils Steinheit Oscillophot

*) L'alimentation pour sonde active PM 9346 est nécessaire.

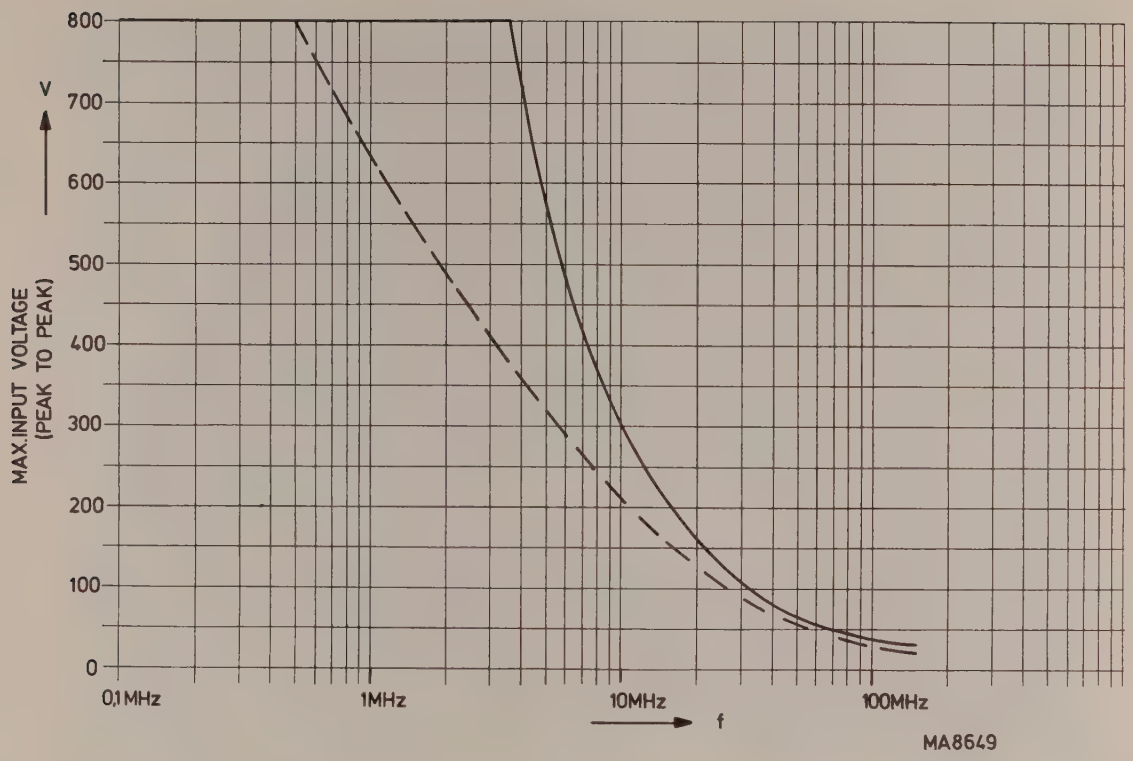


Fig. 1.2. Réduction de la tension d'entrée maximale admise

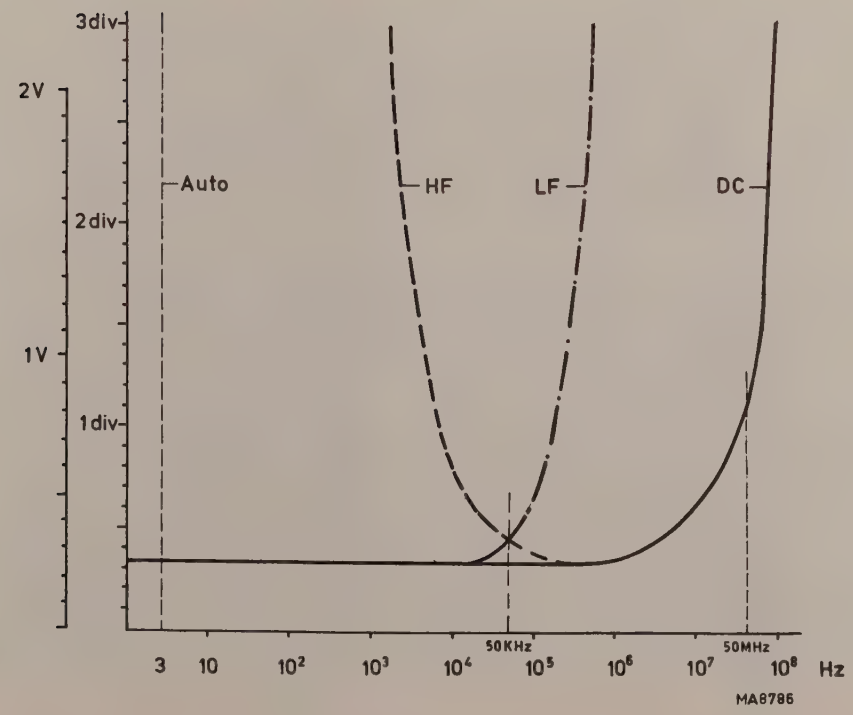


Fig. 1.3. Sensibilités typiques pour déclenchement interne et externe

Fig. 2.1. Dépose du couvercle frontal

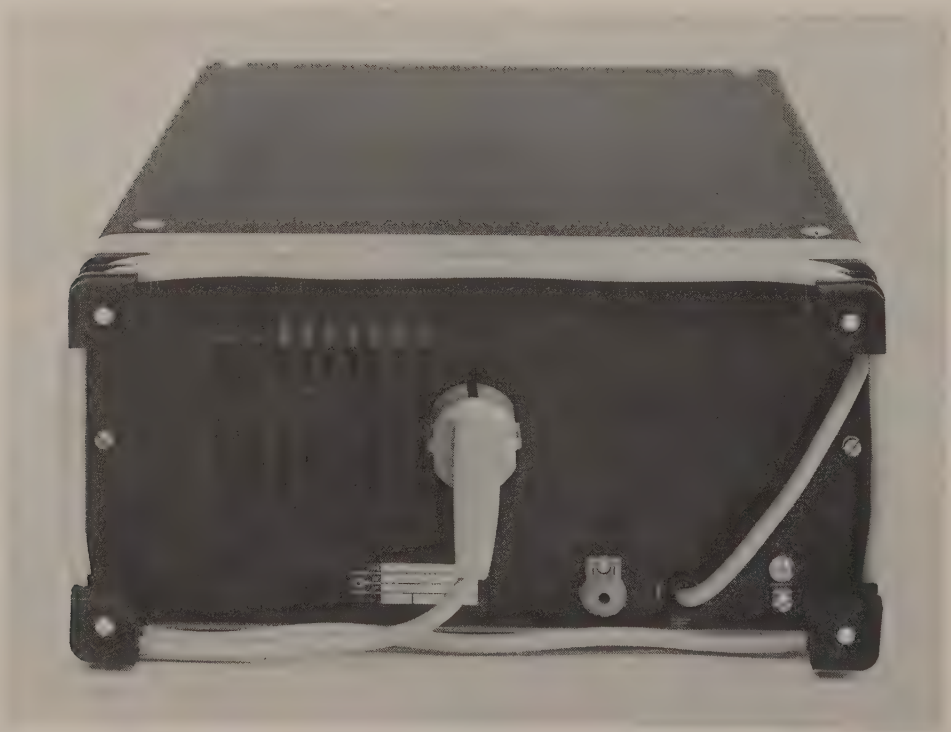


Fig. 2.2. Vue arrière de l'appareil

2. Mode d'emploi

2.1. INSTALLATION

2.1.1. Démontage et montage du couvercle frontal

Démontage:
- Tourner le bouton au centre du couvercle d'un quart de tour vers la gauche (position UNLOCKED)
- Enlever le couvercle

Montage:
- Tourner le bouton de verrouillage vers position UNLOCKED
- Fixer le couvercle sur la partie avant de l'oscilloscope
- Enfoncer le bouton et le tourner d'un quart de tour vers la droite (position LOCKED).

Remarque: Pour faire pivoter la poignée, il faut enfoncer les boutons-poussoirs aux étriers.

Attention: Le présent appareil produit des tensions élevées et ne peut donc pas être utilisé avec les plaques du châssis déposées. La fiche secteur doit être enlevée et tous les points haute tension déchargés avant de procéder à n'importe quel travail d'entretien.

2.1.2. Adaptation à la tension secteur et fusible

La capacité d'utilisation à toute tension secteur comprise entre 90 et 264 V alternatif supprime la nécessité d'adapter le PM 3240 à la tension secteur locale.
La porte-fusible monté sur le panneau arrière porte un fusible à action retardée de 1,6 A. L'utilisation de fusibles réparés et le court-circuitage de porte-fusibles sont vivement déconseillés.

2.1.3. Mise à la terre

A des fins de sécurité l'oscilloscope doit être mis à la terre par l'intermédiaire de la borne prévue à cet effet située à l'arrière de l'appareil (reconnaissable au symbole ⏚) ou par l'intermédiaire du câble secteur, à condition que la fiche soit munie d'une connexion de terre.
Il faut veiller à ce que le conducteur de terre ne soit pas interrompu par l'usage d'un câble ou d'une unité de prolongement non-connectés à un conducteur de terre.

2.1.4. Enclenchement

Le commutateur POWER est incorporé dans la commande d'illumination de graticule ILLUM (panneau avant), juste sous le bord de l'écran.
L'oscilloscope ne doit jamais être enclenché lorsqu'une platine ou un bloc a été enlevé. Ne déposer de platine ou de bloc qu'une minute au moins après la mise hors service de l'oscilloscope.

2.2. UTILISATION

Avant d'enclencher, l'appareil, s'assurer qu'il est installé conformément à la section 2.1. INSTALLATION et que les précautions requises ont êtê prises.

2.2.1. Commandes et prises (Fig. 2.3.)

2.2.1.1. Voies verticales

A/ALT/CHOP/ADD/B	Commandes du mode d'affichage; sélecteur à 5 boutons-poussoirs
A	La déviation verticale est obtenue seulement par le signal appliqué à l'entrée de la voie A.
ALT	L'affichage est permuté d'une voie verticale à l'autre, et ce à la fin de chaque cycle du signal de base de temps.
CHOP	L'affichage est permuté d'une voie verticale à l'autre à une fréquence fixe.
ADD	La déviation verticale est obtenue par la somme des signaux A et B.
B	La déviation verticale est obtenue seulement par le signal appliqué à l'entrée de la voie B. Si aucun bouton-poussoir n'est enfoncé, l'appareil fonctionne la voie A seule ou la voie B seule.
POSITION	Commande continuellement variable pour le positionnement vertical des traces.
NORM/INVERT PULL TO INVERT B	Commutateur push-pull pour l'inversion de la polarité de signal d'entrée (seule voie B)
AMPL.	Commutateur à 9 positions des coefficients de déviation verticale.
AMPL./CAL. (bleu)	Commande continuellement variable des coefficients de déviation verticale. En position CAL. le coefficient de déviation est étalonné.
BAL (accessible par tournevis)	Commande continuellement variable pour l'équilibrage en tension continue des amplificateurs verticaux.
GAIN (accessible par tournevis)	Commande continuellement variable du gain des voies verticales.
AC/0/DC	Mode de couplage du signal d'entrée; commutateur à trois boutons-poussoirs.
AC	Couplage par l'intermédiaire d'un condensateur de liaison.
0	La connexion entre l'entrée de l'amplificateur et la prise d'entrée est interrompue et l'entrée de l'amplificateur est mise à la terre.
DC	Couplage direct Si aucun bouton n'est enfoncé, on obtient le même effet que lorsque le bouton AC est enfoncé.
A 1 MOhm - 15 pF	Prise d'entrée BNC pour voie A
B 1 MOhm - 15 pF	Prise d'entrée BNC pour voie B

2.2.1.2. Voie horizontale

DEL'D TB - EXT. X DEFL - MAIN TB	Commandes de la déviation horizontale; par commutateur à 3 boutons-poussoirs
DEL'D TB	La déviation horizontale est fournie par le générateur de base de temps retardée.
EXT. X DEFL	La déviation horizontale peut être obtenue par un signal d'origine extérieure appliqué à la prise d'entrée de l'amplificateur horizontal, par le signal de voie A, par le signal de voie B ou par un signal à la fréquence du secteur.

MAIN TB

La tension de déviation horizontale est fournie par le générateur de base de temps principale.
Une partie de la trace est intensifiée (sauf en position OFF du commutateur TIME/DIV du générateur de base de temps retardée).
Si aucun bouton n'est enfoncé, on obtient le même effet que lorsque le bouton MAIN TB est enfoncé.

POSITION
TB MAGN

Commande continuellement variable pour le positionnement horizontal des traces; cette commande comprend un commutateur push-pull que augmente le coefficient de déviation horizontale d'un facteur 5.

2.2.1.3. Générateur de base de temps principale

LEVEL
SLOPE

Commande continuellement variable pour sélectionner le niveau du signal de déclenchement, auquel le générateur de base de temps principale démarre. Cette commande comprend un commutateur push-pull, qui permet de déclencher sur le front positif ou négatif du signal de déclenchement.

NOT TRIG'D

Lampe témoin qui s'allume lorsque le générateur de base de temps principale est en position d'attente.

AUTO - TRIG - SINGLE

Commande de mode de déclenchement; commutateur à trois boutons-poussoirs.

AUTO

Le générateur de base de temps principale est en fonctionnement libre en l'absence de signaux de déclenchement.

TRIG

Le générateur de base de temps est déclenché normalement.

SINGLE

Le générateur de base de temps ne démarre qu'une seule fois à la réception d'une impulsion de déclenchement.
Si aucun bouton n'est enfoncé, l'appareil fonctionne en mode SINGLE.

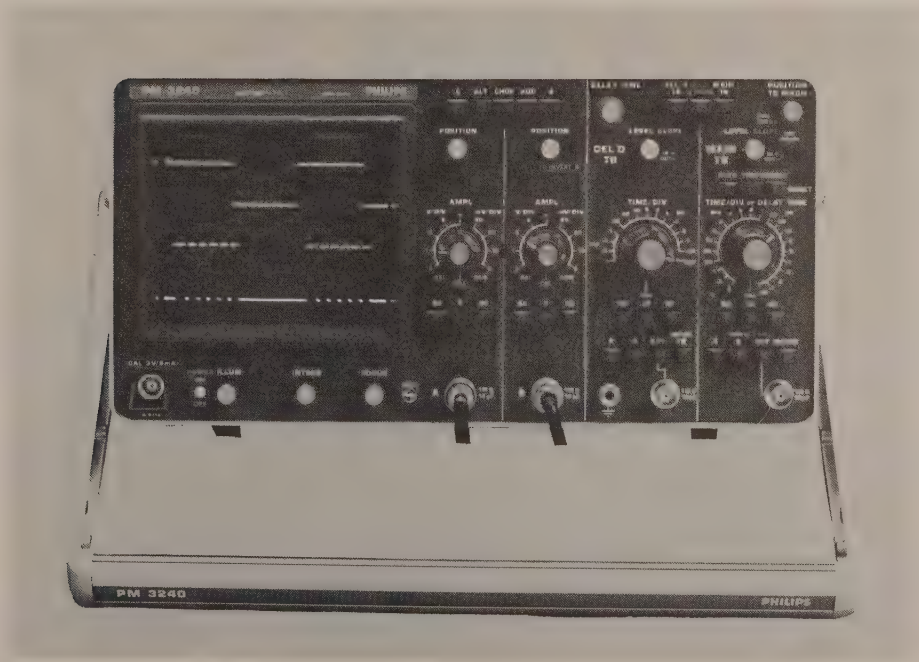


Fig. 2.3. Vue avant de l'appareil

TIME/DIV or DELAY TIME — Commande de la vitesse de balayage de la base de temps principale; commutateur rotatif à 22 positions.

TIME/DIV - CAL (bleu) — Commande continuellement variable de la vitesse de balayage de la base de temps principale. (En position CAL, la vitesse de balayage est étalonnées).

DC - LF - HF — Choix du couplage de déclenchement: commutateur à 3 positions

DC — Les signaux de déclenchement sont couplés directement.

LF — Couplage par le filtre passe-bas pour des fréquences allant jusqu'à 50 kHz (de 10 Hz à 50 kHz pour déclenchement externe).

HF — Couplage par un filtre passe-haut pour des fréquences supérieures à 50 kHz.
Si aucun bouton-poussoir n'est enfoncé, on obtient le même effet que si la touche DC était enfoncée.

TRIG ou X DEFL — Commutateur à 4 boutons-poussoirs qui permet de sélectionner ou la source de déclenchement ou la déviation X par une source extérieure

A — Signal de déclenchement interne ou de déviation X provenant de la voie A.

B — Signal de déclenchement interne ou signal de déviation X provenant de la voie B.

EXT — Déclenchement par un signal externe appliqué à la prise adjacente 1 MOhm - 15 pF.
Lorsque le bouton EXT X DEFL des commandes de déviation horizontale est enfoncé, cette prise est connectée à l'entrée de l'amplificateur horizontal.

MAINS — Signal de déclenchement ou de déviation X provenant d'une tension interne à la fréquence du secteur.
Si aucun bouton-poussoir n'est enfoncé, on obtient le même effet que si le bouton A était enfoncé.

1 MOhm - 15 pF — Prise BNC pour déclenchement externe ou déviation horizontale.

2.2.1.4. Générateur de base de temps retardée

DELAY TIME MULTIPLIER — Commande continuellement variable du temps de retard, utilisée en association avec les commandes TIME/DIV du générateur de base de temps principale.

LEVEL
SLOPE — Commande continuellement variable qui permet de sélectionner le niveau du signal de déclenchement auquel le générateur de base de temps retardée démarre. Cette commande comprend un commutateur push-pull qui permet de démarrer sur le front positif ou négatif du signal de déclenchement.

TIME/DIV — Commande du coefficient de temps pour base de temps retardée; commutateur rotatif à 15 positions.
Comprend une position OFF, grâce à laquelle le générateur de base de temps retardée est déclenché.

TIME/DIV - CAL (bleu) — Commande continuellement variable du coefficient de temps de la base de temps retardée. En position CAL, le coefficient de temps du commutateur est étalonné.

DC - LF - HF — Couplage de déclenchement; commutateur à 3 boutons-poussoirs.

DC	Les signaux de déclenchement sont couplés directement.
LF	Couplage par un filtre passe-bas pour les fréquences jusqu'à 30 kHz (pour le déclenchement par un signal exterieur, le filtre passe-bas agit de 10 Hz à 30 kHz)
HF	Couplage par un filtre passe-haut pour fréquences supérieure à 30 kHz. Si aucun bouton n'est enfoncé, on obtient le même effet que si le bouton DC était enfoncé.
A - B - EXT	Commande de la source de déclenchement; commutateur à 3 boutons-poussoirs.
A	Signal de déclenchement interne prélevé de la voie A
B	Signal de déclenchement interne prélevé de la voie B
EXT	Déclenchement par application d'un signal externe à la douille adjacente 1 MOhm - 15 pF. Si aucun bouton n'est enfoncé, on obtient le même effet que si le bouton A était enfoncé.
MAIN TB	Base de temps retardée est demarrée immédiatement après le temps du retard.
1 MOhm - 15 pF	Prise d'entrée BNC pour le signal de déclenchement externe.

2.2.1.5. Tube à rayons cathodiques

ILLUM POWER	Commande continuellement variable de l'illumination de graticule; comprend le commutateur secteur. La lampe témoin indique la position ON.
INTENS	Commande continuellement variable pour la brillance de la trace.
FOCUS	Commande continuellement variable pour la focalisation du faisceau.

2.2.1.6. Divers

CAL	Prise de sortie sur laquelle une tension rectangulaire de 3 V_{cc} et un courant de 6 mA sont disponibles à une fréquence de 2 kHz. Précision d'amplitude: ±1 % Précision de fréquence: ±2 % La sortie est protégée contre les courts-circuits continus.
⏚	Douille de terre de mesure

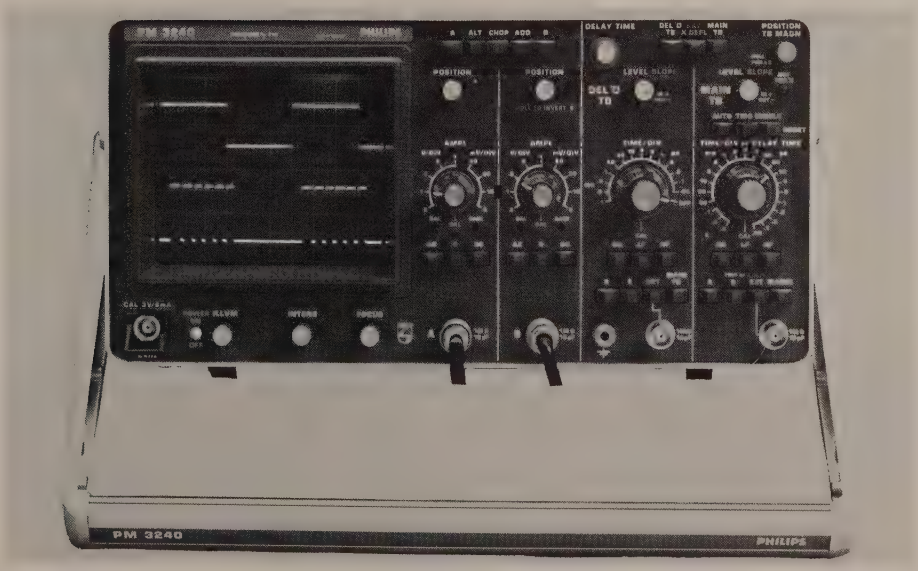


Fig. 2.3. Vue avant de l'appareil

2.2.2. Réglages préliminaires

Etant donné que les réglages suivants sont identiques pour les deux voies verticales, seul le processus pour la voie A est décrit.

2.2.2.1. Réglage de la balance continue

- Actionner le bouton-poussoir A des commandes de mode d'affichage.
- Actionner le bouton-poussoir AUTO des commandes de mode de déclenchement.
- Actionner le bouton-poussoir MAIN TB des commandes de déviation horizontale.
- Régler le commutateur AMPL sur 5 mV et la commande continue sur CAL (étalonnée).
- Centrer la trace avec la commande POSITION.
- Régler les commandes INTENS et FOCUS afin d'obtenir une trace nette et fine.
  Les commandes non-mentionnées peuvent occuper n'importe quelle position.
- Vérifier si la trace ne saute pas lorsque le commutateur AMPL est commuté entre les positions 5 et 10 mV.
  Au besoin, rajuster la commande BAL sur le panneau avant placée immédiatement sous la commande AMPL.

2.2.2.2. Réglage du gain

Sauf indications contraires, les commandes occupent la même position que pour le processus de réglage précédent.
- Régler le commutateur AC-0-DC sur DC.
- Régler le commutateur AMPL sur .5 V et la commande continue sur CAL (étalonnée).
- Connecter la prise d'étalonnage CAL à la prise d'entrée A.
- Vérifier si la hauteur de trace est exactement de 6 divisions.
  Au besoin, rajuster la commande GAIN sur le panneau avant, juste sous le commutateur AMPL.

2.2.3. Entrées A et B et leurs possibilités

L'oscilloscope est pourvu de deux voies identiques, toutes deux pouvant être utilisées soit pour des mesures YT avec un ou deux générateurs de base de temps, soit pour des mesures XY avec la voie horizontale externe.

2.2.3.1. Mesures YT

Pour afficher un signal d'une des voies verticales, il suffit d'actionner le bouton-poussoir A ou B des commandes de mode d'affichage.
Lorsque le bouton-poussoir ALT ou CHOP est enfoncé, deux signaux différentes peuvent être affichés simultanément. Le coefficient de déviation Y et la polarité peuvent être sélectionnées pour chaque voie séparément. Lorsque le bouton ALT est actionné, l'affichage est commuté d'une voie à l'autre au retour du signal de base de temps.
Quoique le mode ALTERNATE puisse être utilisé à toutes les vitesses de balayage du générateur de base de temps, le mode CHOPPED donne une meilleure qualité d'affichage pour des vitesses de balayage lents en effet pendant les temps de balayage longs, l'affichage alterné des deux signaux d'entrée est visible.

En mode CHOPPED, l'affichage est permuté d'une voie à l'autre à une fréquence fixe.
Si le bouton-poussoir ADDED du commutateur de mode d'affichage est actionné, les signaux des deux voies verticales sont additionnées. En fonction des positions du commutateur de polarité de voie B, la somme ou la différence des signaux d'entrée est affichée. Le mode ADDED permet également des mesures différentielles.

2.2.3.2. Mesures XY

Si les boutons-poussoirs EXT X DEFL des commandes de déviation horizontale et A des commandes TRIG OR X DEFL sont actionnés, les générateurs de base de temps sont déconnectés. Un signal appliqué à la voie verticale A est alors utilisé pour la déviation horizontale. Le commutateur AC/0/DC et l'atténuateur par échelons de la voie A restent en service. La commande continue des coefficients de déviation est possible avec la commande X DEFL/HOLD OFF et le décadrage de la trace horizontale avec la commande X POSITION.

La voie verticale B peut également être utilisée pour la déviation X pour ce faire, le bouton B des commandes TRIG OR X DEFL doit être enfoncé.
Pour la déviation X, il est également possible d'utiliser une tension interne à la fréquence du secteur ou un signal extérieur appliqué à la douille EXT située sur la partie inférieure droite du panneau avant ceci, après avoir enfoncé le bouton-poussoir correspondant des commandes TRIG OR X DEFL.

2.2.3.3. Commutateur AC/0/DC

Les signaux observés sont appliqués aux prises d'entrées A et/ou B et le commutateur AC/0/DC est réglé soit sur AC soit sur DC en fonction de la composition du signal. Du fait que l'amplificateur vertical est couplé directement, tout la bande passante de l'appareil est disponible et le composantes continues sont affichées comme des décalages de trace en position DC du commutateur AC/0/DC. Ceci peut ne pas convenir lorsque de petits signaux superposés à des tensions continues doivent être représentés. Chaque atténuation du signal résulte en une atténuation de la petite composante alternative.
Le remède à cet état est d'utiliser la position AC du commutateur d'entrée, lequel comprend un condensateur de liaison servant à supprimer les signaux continus et basse fréquence. Lorsque des signaux rectangulaires à basse fréquence sont représentés, on obtient une certaine pente de toit.

En position 0 le signal est interrompu et l'entrée de l'amplificateur est mise à la terre, sur cette position, le niveau 0 V est rapidement déterminé.

2.2.4. Déclenchement

Lorsqu'un signal doit être représenté, la déviation horizontale doit toujours être démarrée à un point fixe du signal, et ce afin d'obtenir une trace stationnaire. Le générateur de base de temps est donc démarré par des impulsions de déclenchement étroites produites dans l'unité de déclenchement et commandé par un signal qui peut provenir: d'un des signaux appliques aux entrées verticales, d'une tension interne à la fréquence du secteur, ou une source extérieur.

2.2.4.1. Couplage de déclenchement

Trois méthodes de couplage de déclenchement sont possibles avec le commutateur DC/LF/HF. En positions HF et LF, la caractéristique de transfert est limitée.
En position DC, le signal de déclenchement reste inchangé.
En position LF, un filtre passe-bande de 0 Hz (10 Hz pour déclenchement externe) à 50 kHz est incorporé.
Cette position peut être utilisée pour réduire l'interférence du bruit.
En position HF, un filtre passe-haut de 50 kHz est incorporé.
Cette position peut être utilisée pour réduire l'interférence du ronflement par exemple.

2.2.4.2. Sélection de la source de déclenchement et réglage du niveau de déclenchement

Le signal de déclenchement est obtenu à partir de la voie A (bouton A enfoncé), de la voie B (bouton B enfoncé), d'une source externe (bouton EXT enfoncé) ou d'une tension interne à la fréquence du secteur (bouton MAINS enfoncé).
Le conformateur d'impulsions de déclenchement est un multivibrateur à double commande commuté par les signaux de sortie d'un amplificateur différentiel.
Le signal de déclenchement, sur lequel la commande continue AMPL n'a pas d'effet, est appliqué aux entrées de l'amplificateur différentiel de concert avec les tensions continues réglables avec le potentiomètre LEVEL.
En fonction du réglage LEVEL, une certaine partie du signal de déclenchement est amplifiée par l'amplificateur différentiel.
Le multivibrateur est donc commuté à un point fixe du signal de déclenchement (voir Fig. 2.4.). Ceci signifie que, s'aidant de la commande LEVEL, il est possible de donner sa forme au signal de déclenchement (en cas de déclenchement interne A ou B égal à la forme du signal à représenter) et donc, de choisir le point où le multivibrateur sera commuté.
Le potentiomètre LEVEL est pourvu d'un commutateur push-pull qui permet la sélection de la pente de déclenchement.

2.2.4.3. Déclenchement automatique

Lorsque le bouton AUTO du commutateur AUTO - TRIG - SINGLE est enfoncé, et qu'aucune impulsion de déclenchement n'est disponible, le générateur de base de temps fonctionne librement.
La trace est alors toujours visible. Le mode AUTO peut être utilisé dans tous les cas où le mode TRIG est également applicable, à l'exception de signaux dont la fréquence est inférieure à 10 Hz et des trains d'impulsions ayant un temps supérieur à 100 ms.
Dès que des impulsions de déclenchement sont disponibles, le fonctionnement libre du générateur de base de temps est automatiquement achevé et le générateur est à nouveau déclenché comme décrit aux paragraphes 2.2.4.1. et 2.2.4.2.
Lorsque les boutons TRIG ou SINGLE sont actionnés, le circuit automatique est mis hors circuit. Le réglage LEVEL peut également être utilisé en mode AUTO.

2.2.4.4. Déclenchement du balayage en SINGLE

Lorsque des effets uniques sont observés (par photographie), il faut s'assurer qu'une seule dent de scie est engendrée, même si plusieurs impulsions de déclenchement doivent être produites après le phénomène en question. Il va de soi que la dent de scie simple en question doit être déclenchée par une impulsion de déclenchement. Pour ce faire, le bouton SINGLE doit être enfoncé. La première impulsion de déclenchement apparaissant après le relâchement du bouton démarre le générateur de base de temps, celui ci est alors bloqué jusqu'à ce que le bouton SINGLE soit enfoncé à nouveau. La lampe NOT TRIG'D s'allume dès que le bouton SINGLE est relâché, et ce jusqu'à la fin de la dent de scie.

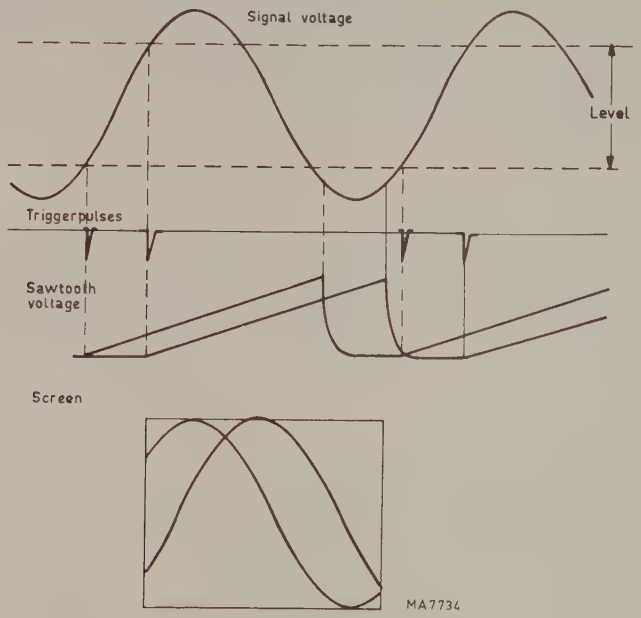


Fig. 2.4. Analyse de la forme d'onde à l'aide du potentiomètre LEVEL

2.2.5. Agrandisseur de base de temps MAGN

L'agrandisseur de base de temps est actionné par un commutateur push-pull à deux positions incorporé dans la commande POSITION horizontale. Lorsque ce commutateur est tiré en position x5, les vitesses de balayage du générateur de base de temps principale sont augmentées d'un facteur 5. Donc, en x1, (TB MAGN enfoncé) la portion du signal affichée sur une largeur égale à une division au centre de l'écran ocuppe la largeur totale de l'écran en position x5. Chaque portion de la trace peut être raportée sur l'écran à l'aide de la commande de POSITION horizontale.
En position x5, le coefficient de temps est déterminé en divisant par 5 la valeur TIME/DIV.

2.2.6. Utilisation de la base de temps retardée

La base de temps retardée peut être utilisée pour l'étude précise de signaux complexes. Lorsque le bouton-poussoir MAIN TB du commutateur de la source de déclenchement est actionné, la base de temps retardée est immédiatement enclenchée (le commutateur TIME/DIV n'est par sur OFF) et une portion du signal affiché est intensifiée en position MAIN TB des commandes de déviation horizontale. La commande DELAY TIME permet de décaler cette partie intensifiée le long de l'axe des temps. La durée de cette portion intensifiée ainsi que sa longueur peuvent être commandées par échelons et ce de façon continue à l'aide des commandes TIME/DIV du générateur de base de temps retardée. Lorsque le bouton-poussoir DEL'D TB des commandes de déviation horizontale est enfoncé, la portion intensifiée occupe la largeur totale de l'écran. En position DEL'D TB, le retard (c.à.d., l'intervalle entre le point de démarrage de la base de temps principale et le point de démarrage de la base de temps retardée) est déterminé par les réglages des commandes TIME/DIV principales et de la commande DELAY TIME.

Lorsque le bouton A, B ourEXT. du commutateur de la source de déclenchement est enfoncé, la base de temps retardée est démarrée par la première impulsion de déclenchement qui apparaît le retard sélectionné. Cette impulsion de déclenchement est produite par l'impulsion de déclenchement du générateur de base de temps retardée. Cette position est utilisée pour éviter une instabilité de la base de temps, laquelle donne une représentation floue d'un détail. Cette instabilité peut fair partie du signal à analyser ou, pour des agrandissements extrêmes, être produite dans les circuits de base de temps.

Service manual

3. Service manual

3.1. DESCRIPTION OF THE BLOCK DIAGRAM (Fig. 3.1)

3.1.1. General information

The PM 3240 oscilloscope comprises the following parts:
– a dual-channel vertical deflection system
– a main time-base
– a delayed time-base
– a switching unit
– an X amplifier
– a Z modulator and c.r.t. circuit
– e.h.t. supplies
– a stabilized power supply.

3.1.2. Dual-channel vertical deflection system

Both the A and B vertical channels are almost identical circuits.
Channel B has a switch facility for signal inversion. The input signal to each channel is fed via a three-position coupling switch AC/0/DC to the input attenuator. In the AC position a capacitor is switched in series with the signal path. In the 0 position the input signal path is interrupted and attenuator input is earthed.

The input attenuator, controlled by the AMPL switch via reed relays, enables the adjustment of the vertical deflection sensitivity in calibrated steps. This attenuator consists of a high and low impedance part separated by a low-drift impedance converter. The d.c. balance of the entire channel is set by a BAL potentiometer which compensates for the d.c. offset voltage of the impedance converter.

The output signal of the attenuator is, via a 50-Ω-coaxial cable, applied to a pre-amplifier stage in the intermediate amplifier where it is transformed into a push-pull current signal. The GAIN control varies the emitter current of the following stage, which is direct-coupled to a cascode voltage amplifying stage. This cascode amplifier provides the following functions:

– a signal for the trigger preamplifier
– shift for the Y trace by means of the POSITION control
– electronic switching of the selected channel modes
– phase inversion of the B channel by means of the PULL TO INVERT B switch.

The channel selector enables or inhibits the Y-signals as dictated by the channel selection logic. In the A, B, and ADD modes the channel selector logic setting depends of the vertical-display mode switch. In the ALT mode the channel selector logic is controlled by pulses derived from the sweep-gating multivibrator of the main time-base generator. In this way, the complete signal trace of channel A and channel B are alternately displayed on the c.r.t. screen.

In the CHOP mode the channel selector control pulses are derived from an oscillator running at a fixed frequency of approximately 2 MHz. These pulses cause the electronic switch in the channel selector to be successively opened and closed so that portions of the signals of channel A and channel B are alternately displayed repetitively.

A common output for the A and B channels feeds the delay line, which delays the vertical signals sufficiently to permit the steep leading edges of fast signals to be displayed. A delay-line correction circuit compensates for the distortion introduced by the delay line. A final stage feeds the Y signals to the vertical deflection plates of the c.r.t.

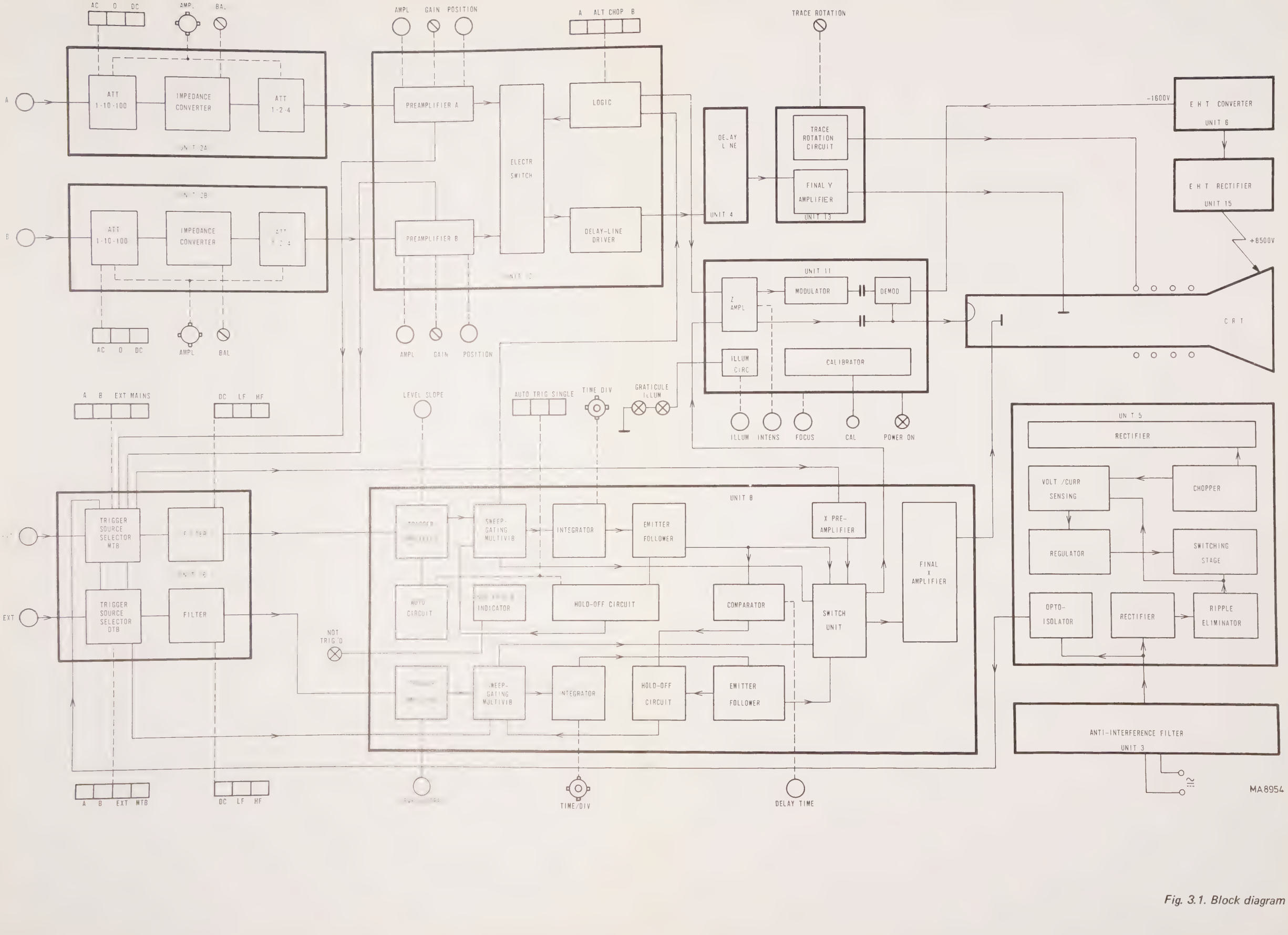


Fig. 3.1. Block diagram

3.1.3. Time-bases

3.1.3.1. Main time-base

The trigger source/X deflection selector receives its signal from one of four sources:
– either A or B vertical channel via its trigger preamplifier
– from the EXT input socket
– from the opto-isolator in the mains power supply.

Selection of these sources is by means of the four-pushbutton unit in this stage.

From the selector stage, the signal is fed to either the X preamplifier for horizontal deflection (when external X signal is employed), or the trigger amplifier for starting the time-base generator. The input of the trigger differential amplifier stage contains the control for selecting the input frequency range of the trigger circuit. The trigger LEVEL adjustment and SLOPE selection switch are also incorporated in this stage. The SLOPE selector switches the differential amplifier to invert the polarity of the trigger signal to enable triggering of the input signals on either positive- or negative-going slopes.

The output of the trigger amplifier is applied to the trigger multivibrator, which produces well-defined trigger pulses. These trigger pulses are used to switch the sweep-gating multivibrator and, when the AUTO pushbutton has been selected, for driving the automatic circuit.

The sweep-gating multivibrator controls the starting and stopping of the integrator circuit that produces the sawtooth waveform required for the horizontal deflection. The integrator circuit consists of charging capacitors switched by transistors, and the resistors selected by the TIME/DIV switch to set the time coefficients in calibrated steps. Continuous control of these time coefficients is obtained by varying the charging current of the time-determining capacitors by means of the TIME/DIV potentiometer.

The resulting sawtooth signal of the integrator is fed to the X deflection selector, the hold-off multivibrator and the comparator which is part of the delayed time-base unit. The hold-off multivibrator resets the sweepgating multivibrator and inhibits its input during the flyback period of the sawtooth waveform. The hold-off circuit also incorporates the single-sweep circuit which causes the main time-base to produce a single sawtooth waveform after the SINGLE pushbutton has been depressed and on receipt of a trigger pulse.

The automatic free-run circuit or auto-circuit makes the time-base free-running when no trigger pulses are applied.

3.1.3.2. Delayed time-base

In principle, the delayed trigger-unit and time-base generator use similar circuits to those of the main trigger-unit and time-base generator. The delayed time-base always operates in the single-shot mode. The sweep is initiated by the main time-base generator which also serves as hold-off circuit for the delayed time-base.

The DELAY TIME control in conjunction with the comparator and reset multivibrator determine the delay time for the delayed time-base generator. The delayed time-base is operative unless its TIME/DIV switch is in the OFF position. It starts immediately after the delay time, or upon receipt of the first trigger pulse after the delay time. It can be triggered by the A, or B channels, or externally.

When pushbutton MAIN TB of the horizontal deflection mode controls is selected, the part of the trace coinciding with the delayed sweep is intensified.

3.1.4. Switching unit and X amplifier

The X deflection selector couples the external X deflection signal from the X preamplifier, the output of the main time-base generator or the output of the delayed time-base generator to the X amplifier and from there to the horizontal deflection plates. The X amplifier comprises the horizontal trace positioning and 5x magnification controls.

The blanking pulse selector supplies blanking pulses to the Z amplifier. These pulses blank the trace at the end of the sweep of the main time-base and provide the extra bright-up pulse if the oscilloscope operates with a portion of the trace intensified. The blanking pulses during the switching of the traces in the chopped mode go direct from the channel selector logic to the Z amplifier.

3.1.5. Z Amplifier and c.r.t. circuit

The Z amplifier receives two input signals. One originates in the time-base generator and is, via the switching circuit, applied to the Z amplifier to blank the trace during flyback. The other one is supplied by the channel selector logic to blank the trace during switching from channel to channel in chopped mode.

The INTENS potentiometer determines the amount of input current fed to the Z amplifier. At the output of the amplifier, the signal is split into two parts: an l.f. + d.c. part and an h.f. part. The h.f. part is fed direct to the Wehnelt cylinder of the c.r.t. The l.f. + d.c. part is modulated on to an oscillator signal and afterwards detected in a peak-to-peak detector. Both signals parts are combined again on the Wehnelt cylinder.
The c.r.t. circuits comprise the focus control and preset potentiometers for trace rotation, astigmatism and distortion.

The high voltage for the post-acceleration anode of the c.r.t. is supplied by a stabilised oscillator whose output voltage is rectified and multiplied by a factor of 5.

The calibrator, an integral part of the oscilloscope, is a square-wave generator which supplies an accurate voltage and current for calibration purposes.

3.1.6. Stabilized power supply

The mains voltage is full-wave rectified and fed to a voltage regulator. The voltage regulator contains a current sensor which controls in such a way that the output voltages of the power supply stay within specified limits. The rectified mains voltage controls a blocking oscillator which generates a voltage at a frequency of approximately 20 kHz. This voltage is applied to the primary of a transformer. The secondary voltages of this transformer are full-wave rectified, smoothed and applied to the various circuits.

The MAINS triggering signal is taken direct from the mains and, via an opto-isolator, fed to the trigger circuits at a safe level.

3.2. CIRCUIT DESCRIPTION

3.2.1. Vertical Deflection System

3.2.1.1. Input Stage (Fig. 3.20)

The input stage of the vertical deflection system comprises two identical input attenuator units, A and B, each consisting of a triple high-ohmic and a triple low-ohmic voltage divider stage separated by an impedance converter stage. The latter stage is an integrated circuit block, IC101. For convenience, only the A unit is described.

The overall attenuation of the input stage is determined by the combination of the selected sections of both voltage dividers. The various combinations are selected by reed relays that are controlled by the position of the front-panel attenuator switch (SK10).

The high-ohmic voltage divider sections attenuate by a factor of 1x, 10x and 100x, each section being switched by two reed relays. In combination with the common parallel resistor R108 the attenuation is increased to 1.25x, 12.5x and 125x. The low-ohmic voltage divider gives attenuations of 1x, 2x and 4x at outputs 2, 5 and 8 respectively. With the overall combinations of attenuation, nine Y deflection coefficients are realised from 5 mV/DIV to 2 V/DIV in a 1-2-5 sequence.

Constant input capacitance for the various attenuator positions is achieved by trimmers C102, C107 and C111. The high-ohmic voltage divider sections are made independent of the input frequency (i.e., the capacitive attenuation for a.c. signals is adjusted to the resistive attenuation for d.c. signals) by means of trimmers C101, C108 and C109.

Diode GR101, interposed after these voltage divider sections, protects the input source-follower of the impedance converter from excessive negative voltage excursions. The input circuit of the impedance converter can handle positive voltages.

The front-panel preset potentiometer, BAL, maintains the input circuit balance in the various positions of the high-ohmic voltage divider.

The output impedance of the attenuator stage is 50 ohms in all attenuator positions, thus presenting a correct impedance match for the coaxial cable link to the intermediate amplifier that follows.

Input coupling switch, SK16 (pushbutton AC-0-DC) forms part of the input attenuator stage. When the AC position is selected, capacitor C104 is connected in series with the input and reduces the lower frequency limit to 10 Hz. When the DC position is selected, RE106 is energised and C104 is bypassed via resistors R109 and R111 in series. Selection of the 0 pushbutton energises RE108 to provide an earth path for the impedance converter input via R114. In addition, it de-energises all other attenuator reed relays to isolate any external signals applied to the Y input.
Any d.c. off-set at the output of the attenuator is compensated by R129.
Note that the value of R122 depends on the colour indication on the impedance converter circuit block.

3.2.1.2. Intermediate amplifier (Fig. 3.24)

The intermediate amplifier comprises integrated circuits wherever there is the need for greater stability to safeguard against drift. As the signal paths for channel A and channel B are basically identical, only the channel A signal path is described.

The output signal from the channel A attenuator is applied via R306 to point 9 of IC301. This portion of the integrated circuit block consists of a differential amplifier using discrete transistor TS301 in the common-emitter tail circuit as a constant-current source to achieve high rejection. The RC network R308, C302 and C303 constitutes the h.f. response correction filter with C302 as the adjusting element. In this part of the circuit, the overall gain of the channel is adjustable by means of the front-panel preset GAIN control, R16, and the AMPL continuous control, R11, of the Y deflection coefficients. These control the signal current to the emitters of two transistors in common-base mode, which are also part of IC301.

This stage is followed by two discrete pnp transistors, TS302 and TS303, connected in common-base mode, which lower the d.c. potential. The collector outputs are resistor-coupled to the bases of an amplifier forming part of IC302. The emitters of this stage are fed from a constant-current source transistor, TS304. An h.f. correction network is also part of the common-emitter circuit, the adjusting elements of which are R342 and C316.

Trigger preamplifier

The emitters of the IC302 amplifier (pins 7 and 8) are also coupled to the bases of the trigger preamplifier, TS306 and TS308. Transistor TS307 provides a constant-current source for this preamplifier. A preset potentiometer, R351, in its base circuit provides a d.c. control for the trigger signal.
The output from the trigger preamplifier is routed from the collector of TS306 via R348.

Buffer stage

The intermediate amplifying stages are isolated from the channel selector by two buffer amplifiers, TS313 and TS309, in common-base mode.
The front-panel POSITION potentiometer, R3, controls the position of the A display by dividing the output from a current-source from TS317 between two transistors, TS314 and TS316. These, in turn, control the direct currents of the transistors in the channel selector, which causes a voltage change over the collector resistors R514 and R517.

Pull to Invert B circuit

The B channel has provision for inverting the polarity of the Y signal. Pull switch SK27, PULL TO INVERT B, is mounted on the spindle of front-panel control R7. In the invert position the normal signal paths are blocked because TS413 and TS409 are switched off.
Inversion is achieved by TS411 and TS412 providing alternative paths for the signal when their bases are switched less legative by SK27. Possible unbalance between the two positions of the switch can be compensated by preset potentiometer R435 between the +12 V rail and earth.

Channel selector (channels A and B described)

Channel switching is achieved by the channel selector comprising part of circuit blocks IC302, IC402, actuated by control signals originating in the Channel Selection Logic, described in the following section, 3.2.1.3. In the channel selector, switching diodes control the bases of the A and B channel output transistors, also part of IC302 and IC402. The collectors of these transistors are commoned to feed the output stage, TS503 and TS506, coupled to the delay line. The output signals that can be selected are: channel A only; channel B only; channels A and B added, chopped, or alternately displayed.

Switching transistors TS501 and TS502 enable or inhibit the two channels according to logic signals received from the channel selection logic. For example, the B channel is inhibited by a "low" signal (0 V) at the base of TS502. This allows TS502 to conduct and current is drawn via the diode network. As a result, the B channel output transistors are switched off.
The B channel is enabled by a "high" signal (+5 V), which switches off TS502 and makes the diode network non-conducting.

The A channel is switched is a similar manner to that described for the B channel. In the ADD mode, both channels are enabled and switch SK1 (D) short-circuits diode GR501 to provide the extra power requirements for the simultaneous display of both channels.

3.2.1.3. Channel selection logic (Fig. 3.25)

The channel selection logic consists of digital circuits employing dual-in-line integrated circuits IC1601, IC1602 and IC1603. Vertical display mode selection is made by the five-pushbutton switch, SK1. The outputs 3 and 6 of IC1602 are connected to the bases of TS501 and TS502 respectively in the channel selector stage of the intermediate amplifier.
Positive logic is used in the digital circuits, the levels being as follows:

logic "1": +5 V (high)
logic "0": 0 V (low)

As described in the previous section, positive outputs (logic "1") enable the A and B channels. The levels on outputs 3 and 6 of IC1602 are determined by JK flip-flop IC1603.
The different functions of the logic circuit are now described according to the operation of the display-mode controls.

SK1: A — selects channel A only. Input 2 of the JK flip-flop IC1603 is low, consequently output 6 is high. Input connection 5 to gate IC1602 is therefore high and the resulting low output on pin 6 blocks channel B. Output 8 of the JK flip-flop is low, consequently output 3 of IC1602 is high and channel A is enabled.

SK1:B — selects channel B only. Input 13 of the JK flip-flop IC1603 is low, consequently output 8 is high. Input 2 to gate IC1602 is therefore high and the resulting low output on pin 3 blocks channel A. Output 6 of the JK flip-flop is low, consequently output 6 of IC1602 is high and channel B is enabled.

SK1: ADD — adds channels A and B. Gate inputs 1 and 4 of IC1602 are both low and consequently both outputs 3 and 6 remain high irrespective of the state of the JK flip-flop. Both A and B channels are therefore enabled.

For convenience, the foregoing logic functions are summarised in the following truth table:

MODE	JK FLIP-FLOP				IC1602		
Pushbutton	inputs		outputs		gate	outputs	RESULT
SK1	2	13	6	8	3	6	
A	low	(high)	high	low	high	low	ch. A ENABLED
B	(high)	low	low	high	low	high	ch. B ENABLED
ADD	(high)	(high)	hi/lo	lo/hi	high	high	chs. A+B ENABLED

SK1: CHOP — selects channels A and B chopped. In this position a chopper generator (part of IC1601) is switched into the circuit. The pushbutton connects a "low" level to the input (12, 13) of an inverter (IC1602) to provide a "high" input at pin 10 of IC1601. This input initiates oscillations due to the feedback loop between pins 9 and 8, and 9 and 11 of IC1601. The frequency of oscillation is 2 MHz. This output is fed via IC1602 (pins 10 and 8) and IC1601 (pins 4 and 6) to trigger input (pin 12) of the JK flip-flop IC1603. In this way, the flip-flop is switched at a frequency of 1 MHz, this signal appearing alternately on inputs 2 and 5 of IC1602. The resulting alternate levels on output pins 3 and 6 provide the chopped control signals for the channel selector IC302, IC402, on the intermediate amplifiers.
During switch-over in the CHOP mode, the c.r.t. is blanked by pulses supplied by transistor TS1601. Normally the transistor is made fully conducting by the +6 V supply, via R1604, to its base.
However, in the CHOP mode the negative-going edges of the 2 MHz chopper signal are differentiated by C1602 and produce positive-going pulses at the collector of TS1601. These blanking pulses are fed to the Z amplifier via R1606.

SK1: ALT — selects channel A and channel B alternately for display. In this mode, the JK flip-flop IC1603 is triggered by the main-time base gating signal which is present at input 2 of IC1601. Outputs 3 and 6 of IC1603 are, in turn, high and low and the input signal applied to the oscilloscope is alternately displayed by the channels A and B.

3.2.1.4. Final Y amplifier (Fig. 3.27)

The final Y amplifier basically comprises two common-base mode transistors, TS601 and TS602 together with circuit block IC601, followed by circuit block IC602 coupled to output transistors TS606 and TS607.

The delay line output is applied to the emitters of TS601 and TS602 via 50 ohm coaxial cables. The collectors of TS601 and TS602 are resistor-coupled to IC601 (pins 6 and 9). This integrated circuit provides h.f. networks between pins 7 and 8 for correction of frequency distortion inherent in the delay line.

The correction networks comprise capacitors and resistors which constitute variable and fixed filters in the emitter circuit. Transistor TS603 provides a constant-current source for this stage.
Collector supplies are derived from the +12 V rail via the series diodes GR601 and GR602.

The inputs to the final amplifier block IC602 are via pins 6 and 9, the bases of two transistors. The potentiometer, R641, in the common emitter circuits provides a preset gain control to allow for changes in circuit parameters; e.g. if a c.r.t. is replaced. Two additional transistors in the circuit block provide constant-current sources.
The outputs of the final amplifier are coupled to the output transistors by diodes GR603 and GR609 which provide d.c. voltage drop. Resistors R649 and R668 supply the normal feed current to the final amplifier from the +45 V rail when there is no signal input.

As the two halves of the output stage are identical, only the output feeding the Y1 deflection plate of the c.r.t. is described. Because of the +6 V feed to the emitter of TS606, the base stands at slightly more than +6 V. Therefore, due to the voltage drop across the series zener diodes GR604 and GR606, the junction of GR603 and GR604 stands at approximately 23 V, being connected via R649 to the +45 V rail. The potential at that junction is maintained at 23 V under signal and no-signal conditions. When the signal applied to pin 6 of the final amplifier demands more current from the 45 V supply, this current is drawn via R656 from the output transistor TS604 to maintain the junction potential of 23 V.

Hence, less current is available for TS606, since transistor TS604 provides constant current. When the signal applied to the final amplifier demands less current, then the current is reversed through R656 to maintain the 23 V potential constant.

In this way, the currents through the output transistors TS606 and TS607 vary in accordance with the signals applied to the bases of the final amplifier. Consequently, the potentials applied to the Y1 and Y2 plates of the c.r.t. are replicas of the signals applied to the Y input sockets.

Coupling capacitor C623 provides a bypass for h.f. signals, to improve the deflection properties at high frequencies.

3.2.2. Main Time-base triggering

The trigger unit of the main time-base generator can select any one of four input sources as follows:
– the signal of channel A
– the signal of channel B
– an external source
– a signal derived from the mains.

All these sources can be used for both triggering and X deflection purposes. Source selection is by means of a four-position pushbutton switch SK21 that feeds the trigger signals to the trigger amplifier and pulse-shaping circuits.

3.2.2.1. Trigger input circuits and amplifier (Fig. 3.29)

Consider first a trigger signal received from the A channel via the preamplifier in the intermediate Y amplifier stages. This signal is coupled via a coaxial cable to a feedback amplifier TS753. The output is fed via emitter follower TS754 to the source selection switch SK21.

The B channel is identical to that described for the A channel.

Consider next a trigger signal applied to the EXT MTB socket BU8. This signal is fed via a potential dividing network and capacitor C702 to the base of emitter follower TS701, which together with a further emitter follower TS702 forms an impedance converter stage. These input transistors are protected against overloads by diode GR701 which bypasses excessive negative signals.

The remaining trigger source facility is from the mains supply. This trigger signal is fed to the trigger unit from an opto-isolator, a photo-coupling device in the power supply unit. The input from C1824 is applied via filter R717, C704 to the trigger source selector switch SK21, and hence to the trigger coupling switch SK19 via resistor R732.

The three-position pushbutton switch SK19 enables choice of either a.c. or d.c. coupling of the input signal selected. In the DC position, resistors R703 and R704 provide a d.c. bypass across capacitor C702.

There are two modes of a.c. coupling; namely, LF and HF. If LF is selected, resistor R729 and capacitor C709 form a low-pass filter network. If HF is selected, capacitor C708 and resistor R734 form a high-pass filter for the signal. In the DC position, both these networks are by-passed by SK19 (DC)

Each of the four input signal sources described, selectable by SK21, can be used for either triggering or horizontal deflection depending on which pushbutton of the three-position horizontal deflection switch SK2 is selected.

3.2.2.2. Trigger amplifier and multivibrator (Fig. 3.29)

When used for triggering, the output of the trigger coupling switch SK19 is fed to the base of emitter follower TS801 which feeds the trigger amplifier. This is a differential amplifier circuit, TS802, TS804, with a constant-current load, TS803, in the common-emitter circuit.

The trigger level is set by means of the front-panel control R10, LEVEL, which controls the base of emitter follower TS806. This, in turn, controls the base of one of the differential amplifier transistors, TS804.

The collector loads of the differential amplifier include transistors TS807 and TS808 fed from the +12 V rail. Switching diodes GR802, GR803, GR804 and GR806 form an electronic switching circuit which is operated by the SLOPE switch, SK5.

The SLOPE switch enables triggering on either the positive-going or the negative-going slope of the triggering signal depending upon the position of the switch. In the –ve position, diodes GR802 and GR803 conduct. Hence, the signal at the collector of TS807 is applied to the base of emitter follower TS809. In the +ve position of SK5, diodes GR804 and GR806 conduct and apply the signal at the collector of TS808 to the base of TS809.

Emitter follower TS809 is coupled to the trigger multivibrator TS811, TS812, which switches over in response to the trigger signals. The resulting square-wave pulses from R836 are differentiated by capacitor C856 on the time-base circuit.

The negative-going spikes cause TS851 to conduct and trigger the sweep-gating multivibrator of the main time-base via R871. The positive-going spikes switch TS852 to control the automatic triggering circuit.

3.2.2.3. Auto-circuit (Fig. 3.30)

Basically, the auto-circuit comprises electrolytic capacitor C858 across the complementary transistors TS853 and TS854. Positive-going trigger pulses at the base of TS854 cause it to start conducting. Likewise, TS853 starts to conduct and capacitor C858 discharges. The output voltage of the auto-circuit is then approximately −10 V. This voltage is applied to the diode GR851 to make it non-conductive. The sweep-gating multivibrator levels are, therefore, such that it is driven by the negative-going trigger pulses received via TS851.

When no trigger pulses are available, TS853 and TS854 are non-conducting and C858 charges. Hence, GR851 conducts and the sweep-gating multivibrator levels are set so that initiation of the sweep is dependent only on the sweep feedback voltage. The main time-base sweep generator is therefore free-running.

3.2.3. Main time-base generator

The main time-base generator comprises the sweep-gating multivibrator, TS857, TS858, feeding switching transistors TS868 and TS869, the latter being effectively in parallel with the time-base capacitors of the integrator circuit. Transistor TS871 is used as a current source to charge these capacitors. Selection of the appropriate timing capacitors is by means of the TIME/DIV switch SK14 via switching transistors TS874 and TS876. The sawtooth voltage is developed across the selected time-base capacitor(s) by charging it to a certain level from the constant-current source. The capacitor is then short-circuited very rapidly which results in the characteristic sawtooth waveform.

The sawtooth voltage is fed to the transistors TS881, TS882, in Darlington pair configuration. This stage feeds the sawtooth voltage to the X deflection selector stage and also back to the input of the sweep-gating multivibrator via the hold-off circuit.
The main time-base generator circuit also includes a stage which serves to indicate whether the main time-base generator is triggered or not (GR1).

The various stages of the main time-base generator circuit are now considered in some detail.

3.2.3.1. Sweep-gating multivibrator (Fig. 3.30)

Sweep-gating multivibrator TS857 and TS858 is controlled by the following signals:
– the negative-going trigger spikes supplied by the main trigger multivibrator via the differentiating circuit,
– the voltage supplied by the hold-off multivibrator,
– the bias voltage supplied by the auto-circuit.

Potentiometer R873 provides a preset control of trigger stability. The collector circuit of TS857 includes TS856 which, as explained in the Y channel selection logic, provides the ALTERNATE control pulses. The output square-wave of the sweep-gating multivibrator is applied to the switching transistors TS868 and TS869.

3.2.3.2. Switching transistors TS868 and TS869

Transistor TS868 is the switching transistor that is effectively in parallel with the selected time-base capacitance. Whenever this transistor receives a positive-going pulse from the sweep-gating multivibrator, it starts conducting and the time-base capacitance is discharged. Transistor TS871 provides the constant-current source to charge the capacitance. Transistor TS869 conducts on the negative-going pulses from the sweep-gating multivibrator and provides unblanking via R903 and GR1062.

3.2.3.3. Sweep speeds

The sweep speed or time coefficient is determined by the value of the time-base capacitance in circuit, and also by the magnitude of the charging resistor selected.

The time-base capacitors are C866, C867 and C869. Capacitor C866 is always in circuit; the other two capacitors are selected by transistors TS874 and TS876. These operate as electronic switches and are either fully cut-off or fully-conducting. They are switched on by the application of a positive voltage to their bases from the TIME/DIV switch. According to the position of SK14, these transistors switch in the relevant capacitor in parallel with C866. As mentioned, the sweep speed is also dependent upon the magnitude of the constant-current charge supplied by transistor TS871. This current can be adjusted in steps by selecting the emitter resistance of TS871 by means of the TIME/DIV switch SK14. Continuous control of the charging current can be effected by varying the base drive to TS871 with the continuous sweep control, TIME/DIV potentiometer R14. In the CAL position of this potentiometer, switch SK15 closes and the charging current is solely determined by the calibrated emitter resistance.

To compensate for the temperature coefficient of the transistor (2 mV/degC) the base voltage of TS871 is supplied via transistor TS872. This also has the advantage of reducing the load on the TIME/DIV potentiometer.

Electrolytic capacitor C868 suppresses any possible ripple and interference present on the supply voltage rail. This transistor, in turn, has its base controlled by preset R914 when SK14 is in position 1 ÷ 8. This provides a fine adjustment for the timing circuit since C867, 4,7 μF, has ±10 % tolerance, whereas the other two timing capacitors have a ±1 % tolerance. In this position, the preset R914 provides an additional measure of control over the base voltage of TS871. In the positions of SK14 when C867 is not in circuit, the diode GR856 is blocked and the preset control R914 is inoperative.

3.2.3.4. Sawtooth take-off circuit

The sawtooth waveform generated by the time-base is applied to the Darlington pair, TS881 and TS882, the emitter output of the latter being coupled to the X deflection selector via GR1058 and GR1057, to the comparator circuit via R937 and to the hold-off circuit of the main time-base via GR857.

3.2.3.5. Hold-off circuit

The hold-off circuit prevents the sweep-gating multivibrator from responding to trigger pulses before the time-base capacitor has fully discharged. The sawtooth output from the Darlington pair is applied via diode GR857 to the base of emitter follower TS879.
Switching transistors TS877 and TS878 select the appropriate hold-off capacitor, according to the position of SK14, in a similar manner to that described for the main time-base integrator timing capacitors.
Capacitor C862 is always in circuit irrespective of the TIME/DIV switch position.

Charging current for the hold-off capacitors flows via transistor TS879. When TS879 cuts off, the discharge current flows through R924. The voltage across the selected hold-off capacitor drives the Schmitt trigger, TS864, TS866, the hold-off multivibrator. The output signal from the hold-off multivibrator is applied to emitter follower TS863 which, in turn, feeds the input of the sweep-gating multivibrator. The emitter-follower TS863 buffers the hold-off multivibrator from the triggering spikes of the trigger pulse-shaping circuits.

Switch SK9 in the base circuit of TS867 is normally open when AUTO and TRIG of the trigger-mode pushbutton switch are selected. However, when SINGLE mode is selected, SK9 provides an earth to the base circuit of TS867 to reset the hold-off multivibrator. Furthermore, since AUTO is not selected, TS879 is cut off via R927 and SK9; consequently, the hold-off multivibrator is no longer reset by the sweep voltage.

When the oscilloscope is used with an external X deflection signal, the internal time-base generator is switched off by depressing the EXT X DEFL pushbutton of SK2. This feeds a +12 V supply via R892 and GR854 to the base of TS867. This transistor holds the hold-off multivibrator so that its output prevents the sweep-gating multivibrator from responding to trigger pulses.

3.2.3.6. "NOT TRIG'D" indicator

Light-emitting diode GR1 in the collector circuit of transistor TS861 serves two purposes:

– it provides a front-panel indication when the time-base generator is not triggered in the AUTO and TRIG modes; i.e., it indicates the absence of trigger pulses. In this condition, TS853 and TS854 are switched off and electrolytic capacitor C858 in the auto-circuit of the main trigger circuit charges. Consequently, the emitter of TS859 becomes less negative and the transistor cuts off. The earth applied via R882 switches on TS861 and the NOT TRIG'D diode, GR1, lights. On receipt of trigger pulses, C858 is discharged, TS859 conducts and cuts off TS861, thus extinguishing GR1, the current being taken over by TS862.

– In the SINGLE mode, the NOT TRIG'D lamp also serves as a reset indicator. On selection of the SINGLE pushbutton, the lamp remains on until the sweep is initiated by a trigger pulse. In this mode, the trigger pulse drives the base of TS859 dependent on the state of the hold-off multivibrator TS864, TS866.

Note: The instrument also operates in the SINGLE mode if none of the trigger-mode pushbuttons is depressed.

3.2.3.7. Delay-time function

The function of the DELAY TIME potentiometer R1 is to provide an adjustable d.c. voltage for comparison with the sweep voltage of the main time-base generator.

This comparison voltage is then used to start the delayed time-base generator at a pre-determined time during the sweep of the main time-base. The comparator circuit is described in the delayed time-base generator section (3.2.5.3.). The DELAY TIME potentiometer is a 10-turn front-panel control.

3.2.4. Delayed time-base triggering

The trigger unit of the delayed time-base is almost identical to that of the main time-base trigger unit, the circuits of which are described in section 3.2.2. Unlike the main time-base trigger unit, the delayed time-base trigger unit has provision for neither external X deflection, nor triggering from the mains frequency. There is, however, provision for triggering by the main time-base (see section 3.2.5.2.).

3.2.5. Delayed time-base generator

As the delayed time-base generator is basically similar to the main time-base generator (section 3.2.3.), only the essential differences are described.

3.2.5.1. Sweep speeds

The delayed time-base integrator circuit is a simplified version of the main time-base generator as there are fewer TIME/DIV ranges. Preset potentiometer R1097 provides a measure of control of the charging current to obtain exactly the same sweep speeds of main time-base and delayed time-base.

3.2.5.2. Hold-off circuit

The sawtooth voltage is coupled via the Darlington pair TS1066, and TS1067, and diode GR1052 to the hold-off multivibrator TS1057 and TS1058. Emitter follower, TS1056 provides the hold-off pulse for the input of the delayed sweep-gating multivibrator, TS1052 and TS1053. Transistor TS1054 is set by means of the comparator output signal direct-coupled to its base. This, in turn, resets the hold-off multivibrator, and thus the sweep-gating multivibrator via TS1056. If no trigger source has been selected, or SK20 is in the MAIN TB position, then the next sweep is initiated. However, if one of the A, B or EXT pushbuttons of SK20 has been selected, no earth is applied via R1071 and the sweep-gating multivibrator is switched over on the receipt of a trigger pulse at the base of TS1052. In the OFF position of the TIME/DIV switch SK12, the sweep-gating multivibrator is switched so that it no longer responds to either the trigger pulses or the reset pulses of the hold-off multivibrator. Similarly, when X-EXT deflection mode is selected on SK2, a +12 V supply via diode GR1064 also inhibits the delayed sweep-gating multivibrator.

3.2.5.3. Comparator

Transistors TS883 and TS884, connected as a long-tailed pair with TS886 as current source, form the comparator circuit. In this circuit, the d.c. voltage set by the DELAY TIME potentiometer R1 is compared with the sawtooth voltage generated by the main time-base.
When the amplitude of the sawtooth at the base of TS883 exceeds the set d.c. voltage applied to the base of TS884, the collector voltage of TS883 goes more negative and, via emitter-follower TS1054, resets the hold-off multivibrator and delayed sweep-gating multivibrator as previously described.

3.2.6. X Deflection selector and blanking switching circuits

These circuits are part of the main time-base printed-circuit board.

3.2.6.1. X Deflection source selector

Depending on the selected position of SK2, the circuit provides for X deflection by the main time-base signal, the delayed time-base signal or the signal from an external source.

The source selector circuit is described according to the pushbutton mode selected.

MAIN TB — In this position of SK2, the +12 V supply is routed via the contacts and R1118 to the junction of diodes GR1057 and GR1058. These diodes conduct and provide a path for the output sawtooth of the main time-base via R1229 to the X amplifier. With the switch in this position, the diode networks, GR1053, GR1054 and GR1066, GR1067 are blocked. Consequently, signals from the delayed time-base and external X deflection preamplifier are not transmitted.

DEL'D TB — In this position of SK2, the +12 V supply is routed via the switch contact and R1108 to the junction of diodes GR1053 and GR1054. These diodes now conduct and provide a path for the output sawtooth of the delayed time-base via R1229 to the X amplifier. With DEL'D TB selected, the signals from the main time-base and external X preamplifier are blocked by the diode networks.

EXT X DEFL — In this position of SK2, the +12 V supply is routed via R1121 to the junction of diodes GR1066 and GR1067. These diodes now conduct and provide a path for the emitter output of TS1072 of the external X preamplifier. Similarly, the diode networks block the main and delayed time-base signals in this position. Another switch contact of SK2 removes an earth from the PULL FOR x5 switch, SK3, as this facility is not available when EXT X DEFL is selected.

3.2.6.2. Blanking pulse switching circuit

The switching transistors for blanking pulses for the main and delayed time-bases are TS869 and TS1059 respectively.

These transistors conduct during the sweep period of their respective time-bases; i.e. during the unblanking periode. Diodes GR1063 and GR1062 connect the collectors of these transistors to the Z amplifier via R1312. During blanking, these transistors are switched off and current is injected via the diodes GR1059 and GR1068, and resistor R1017 to the Z amplifier. This current is 3 mA for complete blanking of the trace.

During the sweep of the main time-base generator 3 mA flows into the main time-base generator via R903 so there is no current for R1312 and the trace is unblanked. If the delayed time-base TIME/DIV switch is at the OFF position, 3 mA flows into the delayed time-base via R1084, R1112. These currents are derived from the +12 V supply, and the potential developed across R1112 prevents TS1068 from being cut off and cuts off GR1063.

The switching is described in accordance with the signal selected by SK2.

MAIN TB — With the TIME/DIV switch of the delayed time-base in the OFF position, TS1059 is permanently on; therefore, GR1063 is blocked. The current step from 0 to 3 mA is then applied to the Z amplifier, via GR1062 during main time-base blanking.

With the TIME/DIV switch of the delayed time-base operative; i.e., not in the OFF position, then bright-up of the main time-base trace by the delayed time-base occurs after the delay time selected. During the part of the sweep where only the main time-base is running (TS1059 cut off), no current flows to the Z amplifier via GR1062; i.e. trace unblanking.

However, the Z amplifier receives a small current from the delayed time-base via GR1063, dependent on the bias of TS1068 and the setting of R1116. Therefore, the trace is not completely unblanked. Immediately the delayed time-base starts TS1059 conducts and the emitter of TS1068 goes negative. Therefore, both TS1068 and GR1063 are cut off. The Z amplifier intensifies the entire trace. At the end of the delayed sweep, the small current flows through GR1063 again and the trace is once again completely unblanked. Potentiometer R1115 allows adjustment of the emitter potential of TS1068, in order to vary the current through R1116 and GR1063 during the time that TS1059 is cut off. Thus, the brightness of the intensified part of the trace can be varied.

Via R1109 this change is also transferred to the INTENS potentiometer (see Z-MOD., section 3.2.9.1.).

DEL'D TB — If the delayed time-base is selected, GR1059 and GR1062 are non-conductive since the +12 V supply of GR1059 ceases. The current for TS869 in the main time-base is supplied by GR1061. Transistor TS1068 is switched off by the conduction of diode GR1056 and the 0 to 3 mA bright-up information is fed to the Z amplifier via diode GR1063.

EXT X DEFL — If the EXT X DEFL pushbutton is depressed, the MTB and also the DTB are switched off. Therefore, there is no current through R1312 and the trace is unblanked.

3.2.7. Pre-amplifier for external X deflection

Transistors TS1069, TS1071 and TS1072, located on the main time-base printed-circuit board, form a pre-amplifier circuit for external X deflection signals. The input signal from R728 on the trigger source unit is routed to the base of transistor TS1071. The input signal may be one of the triggering signals; namely, a signal on the EXT input socket BU8, the channel A or channel B signal, or the mains-derived signal from the opto-isolator (see section 3.2.2.1.).

When the EXT X DEFL position of SK2 is selected the +12 V supply is routed via GR1065 to the emitter of transistor TS1069. The signal is amplified by TS1071 and TS1069 and passed to the emitter follower, TS1072. Since diodes GR1066 and GR1067 are conductive because of the +12 V via R1121, the emitter output signal from TS1072 is passed via R1229 to the X amplifier. In this position, the main and delayed time-base are inhibited from the +12 V supply, routed via GR854 and GR1064 respectively.

3.2.8. X Amplifier (Fig. 3.34)

The X amplifier is part of the time-base printed-circuit board U8. The X amplifier receives the input selected by mode switch SK2. This asymmetrical input voltage is fed to the base of transistor TS1201. Transistor TS1204 provides an anti-phase signal, variable by means of the front panel X POSITION potentiometer R2, to give a symmetrical signal to the next stage.
The potentiometer R2 varies the base bias of TS1204 which unbalances the push-pull amplifier resulting in horizontal trace shift on the c.r.t. screen.

The nominal gain of the amplifier can be increased by a factor of 5 by switching the current-source supply, using transistors TS1202 and TS1203 controlled by the front panel PULL FOR x5 switch, SK3.

Normally, current source TS1203 supplies the emitters of transistors TS1201 and TS1204 via the higher value resistors R1224 and R1222 and the diodes GR1023 and GR1024. However, when the PULL FOR x5 switch is selected, the base of TS1202 becomes less negative by the application of an earth (from SK2) via R1231 and SK3. Consequently, TS1202 conducts and TS1203 switches off. The current source is now via GR1201, GR1202 and the lower value resistors R1211 and R1213, which pass the additional current for the x5 gain increase.

Preset control of the gain is provided in the x1 position by R1223 and in the x5 position by R1209.

The x5 position is inoperative when the EXT X DEFL pushbutton of SK2 is depressed. In this position, the earth is disconnected from the SK2 contact that is coupled to SK3.

The two symmetrical output currents of TS1201 and TS1204 are fed to the final amplifier stages with feedback, for each defl. plate. Since these are identical, only one half is described. Basically, the amplifier comprises a cascode circuit using transistors TS1209, TS1211, with feedback via R1237 and R1242.

The cascode circuit is fed via transistor TS1206 in common-base configuration. Transistor TS1208 provides a constant-current source for the final amplifier stage. Zener diodes, GR1208 and GR1209 maintain the average voltage on the deflection plate X1 of c.r.t. B1 at +15 V. Capacitor C1204 improves the h.f. response and the trimming capacitor C1203 provides phase compensation over the feedback path.

3.2.9. C.R.T. Circuits

3.2.9.1. Z modulator circuit (Fig. 3.35)

Basically, the Z unit comprises an amplifier and a modulator/demodulator circuit for the d.c. and low frequency components of the blanking signal. The latter circuit isolates the Z unit from the high potential (−1600 V) present on the c.r.t. cathode and Wehnelt cylinder.

Input signals to the Z amplifier are received from two sources:
– the blanking pulses from the time-base via R1312,
– the chopper blanking pulses from the channel selection logic via R1313.

As stated in section 3.2.6.2., the blanking current is 3 mA and the unblanking current 0 mA. Transistor TS1302, connected in common-base configuration, feeds the current pulses to the amplifier stage, TS1303, TS1304. Front panel control R20, the INTENS potentiometer, provides an adjustment of trace brilliance by regulating the base bias of TS1301.

The slider of R20 is also coupled to the delayed time-base bright-up circuit via a R1109 to maintain the desired intensity ratio for all settings of R20 (see also section 3.6.2.2.).

A portion of the input current is drained off via TS1301 depending on the setting of R20; the larger the current drain, the more brilliant the trace. Conversely, the more brilliant the trace, the less the common-base transistor TS1302 conducts.

Since TS1302 is cut-off, GR1301 is also non-conductive and a small current flows through R1307 and prevents TS1303 and TS1304 from bottoming.

The blanking signal is passed by TS1302 to the base of TS1303 via GR1301. The diode GR1302 in the collector circuit of TS1302 clamps the black level of the blanking current fed to the amplifier at 3 mA.

The output of the amplifier stage TS1303, TS1304 is coupled to emitter follower TS1306, the output of which switches between 4 V and 40 V approximately for blanking and unblanking respectively. At this point, the a.c. and d.c. components of the blanking signal are routed along different paths. The high frequency components of the signal are passed via capacitor C1308 to the Wehnelt cylinder of the c.r.t. The d.c. and low frequency components of the signal are passed via the low-pass filter R1325, C1306 and R1323 to the emitter of TS1308. Together with TS1307, TS1308 forms a multivibrator, the frequency of which is approximately 100 kHz.

The oscillator output on the collector of TS1308 is therefore modulated by the Z amplifier, the peak-to-peak value depending on the d.c. and l.f. components fed to the emitter of TS1308. The black level can be adjusted by the preset pot. meter R1327. Capacitor C1309 feeds this modulated signal to a peak-to-peak detector and also serves to isolate the high potential present on the c.r.t. cathode circuit. After demodulation by the detector circuit GR1307, GR1308, C1311, R1333, the d.c. and l.f. components are recombined with the a.c. component via R1334 and routed to the Wehnelt cylinder of the c.r.t. via R1336.

3.2.9.2. Focussing circuit

The voltage for the focussing electrode, G3 of the c.r.t., is derived from a potential divider network between the −1600 V supply from the H.T. converter and earth. The slider of the front-panel FOCUS potentiometer R21 is direct-coupled to the focussing electrode.

The cathode bias for the c.r.t. is also obtained from this divider network, the voltage drop across the neon tube B1301 providing the necessary voltage between cathode and Wehnelt cylinder for complete blanking.

3.2.9.3. H.T. Convertor

The −1600 V supply for the cathode, Wehnelt cylinder and focus electrode, and the +8 kV supply for the post-acceleration anode G8 are derived from the h.t. convertor circuit.

Transistor TS1402 together with transformer T1401 forms an oscillator, operating at a frequency of between 25 kHz and 30 kHz. An a.c. waveform of 1600 V is developed across the secondary winding of the transformer. This voltage is rectified by diode GR1403 and smoothed by the filter network C1406, R1409 and C1407, to provide the −1600 V supply.

Regulation is obtained by rectifying (GR1402/C1402) the collector signal of TS1402. The d.c. potential of approx. 85 V thus obtained is compared with the +45 V supply voltage (R1401-R1402) in TS1401.
If the voltage on the collector of TS1402 tends to drop (i.e. the output voltage decreases), TS1402 will start conducting more current and the output voltage increases.

Overload protection is provided by diode GR1402 which switches off if there is excessive current drain throughout GR1403 to the cathode circuit of the c.r.t. This results in the base of TS1401 going positive which reduces its collector current and switches off the oscillator.

The low-pass filter, L1401, C1401, prevents spurious oscillator pulses being fed back into the +45 V supply line.

3.2.9.4. Calibration unit

The calibration unit comprises a built-in square-wave generator using an operational amplifier with feedback loops. The frequency-determining components are resistor R1371 and capacitor C1318.

Point 3 of the operational amplifier IC1301 is kept equal to the average output voltage by capacitor C1317. In this way, the generator is independent of supply voltage fluctuations. Zener diode GR1316 determines the amplitude of the square-wave output, and potentiometer R1362 allows accurate adjustment of output voltage and current. The calibration unit gives an output of 3 V_{p-p}, 6 mA at a frequency of 2 kHz ±2 %. The output is protected against continuous short-circuits.

3.2.10. Power Supply (Fig. 3.39)

The power supply is designed on the switching regulator principle, thus permitting the PM 3240 oscilloscope to be connected to any a.c. mains voltage between 90 V and 264 V, or any d.c. voltage between 90 V and 200 V, without the need for mains voltage adaptors. All voltage output rails are stabilised and a current-limiting circuit protects against overloads.

The basic circuit functions of the power supply are as follows:
– mains rectifier and ripple elimination circuit
– switching series regulator
– chopper circuit
– error sensing and regulator circuit
– current-limiting circuit
– voltage sensing circuit
– secondary supply voltage circuits.

In principle, the power supply operates as follows. After rectification and elimination of the ripple, the smoothed voltage (between 100 V and 370 V) is fed to the switching series regulator. A pulse width modulated switching transistor and commutating diode supply a filter network which averages the voltage output to a fixed d.c. level. This voltage provides the supply for the chopper. The chopper provides the necessary alternating waveform for the supply transformer. In addition, part of the chopper square-wave output is rectified, compared with a reference voltage and is fed back to control the on-off ratio of the switching transistor.

3.2.10.1. Mains rectifier and ripple eliminator

The mains voltage or an alternative source of supply is applied to the mains filter unit via the front-panel POWER switch SK22 and fuse VL1. The balanced filter consists of two double-wound chokes L1801 and L1802, together with capacitors C1801, C1802 and C1803. The output of this filter feeds a second filter consisting of L1800, R1801 and C1804. These filters suppress mains-borne interference to the instrument and also interference from the instrument; e.g., switching transients, to the mains supply.

The mains rectifier GR1801 comprises four diodes in a bridge circuit. The ripple that remains after full-wave rectification is eliminated by the action of transistors TS1801 and TS1802 and their associated components.

The ripple elimination circuit operates as follows. The buffer capacitors C1806 and C1808 are charged to approximately the peak voltage of the mains supply. Assume that the output voltage across capacitor C1808 tends to rise with the instantaneous value of the ripple. Transistor TS1802 then draws less current as its emitter goes more positive. Therefore, less base current is applied to transistor TS1801; consequently, its collector voltage drops and counteracts the tendency for the output voltage to rise. By this means, the d.c. output level coincides with the lower level of the ripple voltage superimposed on the unsmoothed rectified voltage, and the ripple is effectively eliminated.

3.2.10.2. Switching series regulator

Transistor TS1807 is the switching transistor, the base of which is driven by the pulse-width modulated rectangular waveform. The filter network comprises the choke L1803 and the capacitor C1809. A constant current flows through L1803 during the turn-on time of TS1807 via its collector. During the turn-off time, the back e.m.f. of L1803 provides a constant current via the commutating diode GR1804. This action is repeated at a frequency of approximately 20 kHz, the chopper frequency. The output voltage across C1809 is thus dependent upon the turn-on/turn-off ratio of the switching transistor TS1807. Capacitor C1809 is shunted by the series resistor network R1809 and R1811. To facilitate starting, a small base current is fed to transistor TS1807 via resistors R1803, R1804 and R1817.
Note that the value of R1817 depends on the current gain TS1807; refer to chapter "Checking and Adjusting" 3.4.2.7.

3.2.10.3. Chopper circuit

The chopper circuit is formed by transistors TS1804,and TS1806 which, together with the base drive transformer T1801, form a push-pull oscillator. The primary windings 3-4-5 of the converter transformer T1802 provide the collector loads for the chopper transistors. Winding 7-8 supplies the feedback winding of the driver transformer. As the driver transformer T1801 saturates easily, a square-wave signal is generated. As soon as the instrument is connected to the supply, the small base current applied to TS1807 via resistors R1803, R1804 and R1817 causea the transistor to turn on. Capacitor C1809 is thus charges by the collector current as described. The initial base current of the chopper transistors TS1804, TS1806 flows via Z-diodes GR1806 and GR1825. As soon as the chopper starts, the voltage across C1809 drops until TS1807 conducts, controlled by the regulator circuit and the potential across C1809 rises again to ≈ 80 V. During oscillation, a voltage is developed on the centre tap of the driver transformer T1801 of approximately 1 V negative with respect to the anode of GR1808. This negative potential on the base circuit prevents the conduction of both transistors TS1084-06, due to hole-storage capacitance.
Resistor R1800 in series with C1809 prevents parasitic ringing of the circuit.

3.2.10.4. Error sensing and regulator circuit

Regulation of the chopper output is achieved by comparing a portion of its output voltage against a stable reference and feeding the error voltage back via an operational amplifier to control the on/off ratio of the switching transistor. The basic components of the sensing and regulating circuit are primary winding 7-8 of T1802, voltage-regulator integrated circuit IC1801, potentiometer R1834 and transistor TS1809.

The circuit operates as follows. The quare-wave voltage of approximately 9 V_{p-p} across winding 7-8 of T1802 is half-wave rectified by GR1812 and produces a d.c. voltage of approximately −8 V with a superimposed ripple of about 250 mV_{p-p} across capacitor C1817. This ripple voltage is the sensing voltage used for comparison, and is fed to the inverting input 2 of the operational amplifier IC1801 via capacitor C1821. Input 2 is also connected to point 4 of the integrated circuit via R1829. An internal stabilising network between points 4 and 5 results in an input voltage at point 2 of approximately −1 V together with the superimposed ripple of 400 mV_{p-p}. The non-inverting input 3 of IC1801 is connected to the wiper of R1834, the potentiometer that samples the output voltage across C1817 via R1836, R1833 and diode GR1813. Diode GR1813 conducts via R1832 because of the potential across C1816. The ripple voltage is eliminated from the non-inverting input 3 by capacitor C1818 which is coupled between the wiper of R1834 and the positive side of C1817. Although the ripple at the inverting input 3 approximates to a sawtooth waveform, because of the high gain of the amplifier, the output on point 6 is a rectangular waveform.

The on/off ratio of this rectangular waveform is dependent upon the amplitude of the ripple compared with the reference voltage. The frequency of the rectangular waveform is synchronous with the chopper frequency. The rectangular waveform on point 6 is applied to the base of TS1809 which, in turn, controls the on/off time of the switching transistor TS1807.

The overall function of the voltage sensing and regulator circuit is best considered by assuming a change in output. Any tendency for the output to increase would produce an increase in voltage across C1817. The voltage on input 2 of IC1801 will go more negative as result. Likewise, the voltage on input 3 will go more negative, but to a lesser extent because of the limiting action of the potentiometer R1834 and its associated circuit. Because of this differential, input 3 will be more positive with respect to input 2. In terms of the output on point 6, this means that the positive part of the rectangular waveform will be of longer duration over the duty-cycle. This signal is inverted by transistor TS1809, which results in transistor TS1807 being blocked for a longer period. Consequently, the output of the switching series regulator decreases and restores circuit equilibrium. Conversely, any tendency for the output to decrease would result in the switching transistor TS1807 being on for a longer period. The output of the switching series regulator would increase to restore circuit equilibrium.

In addition to output sensing, anticipatory control is provided from the mains voltage. Input 3 of IC1801 is also coupled to the rectified mains voltage via resistor R1806. Any variation in mains voltage will be reflected at the input 3 of IC1801. The resulting differential with respect to input 2 will produce a compensating regulating action as described.

3.2.10.5. Current limiting circuit

A current sensor circuit automatically cuts off the series regulator if excessive current is demanded by the circuit. The current-limiting circuit comprises transistor TS1808, trigger device TS1811 and their associated components.

The current supplied by the power unit flows through the series resistor R1819 and the potential drop across this resistor is used to control transistor TS1808. If the supply current becomes excessive, transistor TS1808 starts to conduct. In turn TS1811 fires and pulls the base of TS1812 to −8 V. TS1809 is now continuously conducting by the base current delivered via R1816 (the output of IC1801 does not draw any current as this is an emittor follower output). By the current through TS1809, the switching transistor TS1807 is then continuously blocked. Consequently, the chopper stops operating. However, the small base current fed to TS1807 via resistors R1803, R1804 and R1817 enables C1809 to charge slowly. When the Z-voltage of GR1806 and GR1825 is reached, the chopper restarts and is switched off again immediately if the overload or short-circuit persists. Depending on the mains voltage, this cycle is repeated approximately every second so long as the fault condition persists.

3.2.10.6. Switching-on voltage-sensing circuit

In similar manner to the current limiting circuit, a voltage sensing circuit cuts off the switching series regulator if, for any reason, the output voltage of the power supply is too low for the operational amplifier IC1801 to give satisfactory control. Voltage sensing is performed by transistor TS1812. During initial switch-on of the instrument, if the output across winding 7-8 is too low, TS1812 is cut off because Z-diode GR1835 is not yet conducting. Consequently, the positive potential developed across C1814 is applied via R1816 to the base of TS1809. This transistor conducts and turns off switching transistor TS1807. The circuit prevents damage to the switching transistor, which could occur if it were operated with insufficient base current.

3.2.10.7. Secondary supply voltages

The primary windings of the supply transformer T1802, as previously stated, are the collector load circuits of the chopper transistors. The secondary windings providing the voltages for the various circuits in the instrument are completely isolated from the mains power supply.

The filament of the c.r.t. is supplied by the voltage across secondary winding 17-18, rectified by GR1822 and smoothed by electrolytic capacitor C1827. The winding is a.c. coupled to earth via C1830.
All other supply feeds are derived from tapping points on a single secondary winding, earthed at a single point to the transformer screen to reduce interference. Each supply is individually rectified and smoothed.

3.2.10.8. Mains opto-isolator

The trigger/deflection source derived from the mains supply is completely isolated from dangerous a.c. voltages by an opto-isolator TS1813. This consists of a light-emitting diode and photo-transistor combined in one envelope. The a.c. mains derived from the mains filters is rectified by diode GR1819 and smoothed by C1823 to provide a d.c. current through the light-emitting diode. A portion of the a.c. mains is superimposed on this d.c. current, the magnitude depending on the setting of preset resistor R1841. The output is routed to R717 in the trigger amplifier via capacitor C1824.

3.3. DISMANTLING THE INSTRUMENT

3.3.1. General information

This section provides the dismantling procedures required for the removal of components during repair and routine maintenance operations. All circuit boards removed from the oscilloscope should be adequately protected against damage, and all normal precautions regarding the use of tools must be observed. During dismantling procedures, a careful note of all leads disconnected must be made so that they may be reconnected to their correct terminals during assembly. For unit-location refer to Figs. 3.2. and 3.3.

Always ensure that the mains supply is disconnected before removing any instrument cover plates.

When removing the E.H.T. cable from the post-acceleration anode of the c.r.t., both the cable connector and the c.r.t. anode contact must be discharged immediately by shorting them to chassis for several seconds with a well-insulated screwdriver.

Damage may result if the instrument is switched on when a circuit board has been removed, or if a circuit board is removed within one minute of switching off the instrument. In Fig. 3.42, 3.43 and 3.44 the cables lay-out between the various units is given.

3.3.2. Instrument cover plates and screen bezel

Both upper and lower cover plates can be removed after the four quick-release fasteners at the corners of each plate have been slackened; do not slacken more than two turns, otherwise the fasteners may come apart.

The screen bezel can be detached by pulling its upper or lower edge.

3.3.3. Knobs

3.3.3.1. Single knobs (Fig. 3.4.)

– Prise off cap A
– Slacken screw (or nut) B
– Pull the knob from the spindle

3.3.3.2. Double knobs (Fig. 3.4.)

– Prise off can A and slacken screw B
– Pull the inner knob from the spindle
– Slacken nut C and pull the outer knob from the spindle

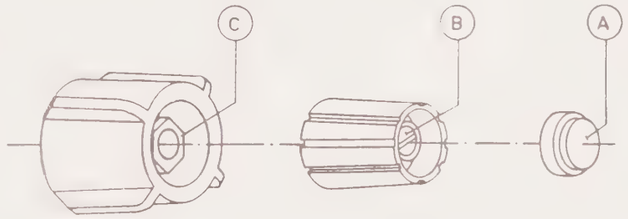


Fig. 3.4. Removing the knobs

When fitting a knob or cap, ensure that the spindle is positioned to allow reference lines to be coincident with the markings on the text plate of the oscilloscope.

3.3.4. Time-base and X amplifier circuit board

This unit is the large rectangular printed-circuit board located on the underside of the instrument adjacent to the c.r.t.

For removal:
– unplug the ten multipole connectors
– unplug the two coaxial plugs on the board
– unsolder two connections to the Z amplifier
– unsolder two trigger input connections
– unplug the X1 and X2 leads from the c.r.t.
– remove the five screws securing the circuit board to the chassis.

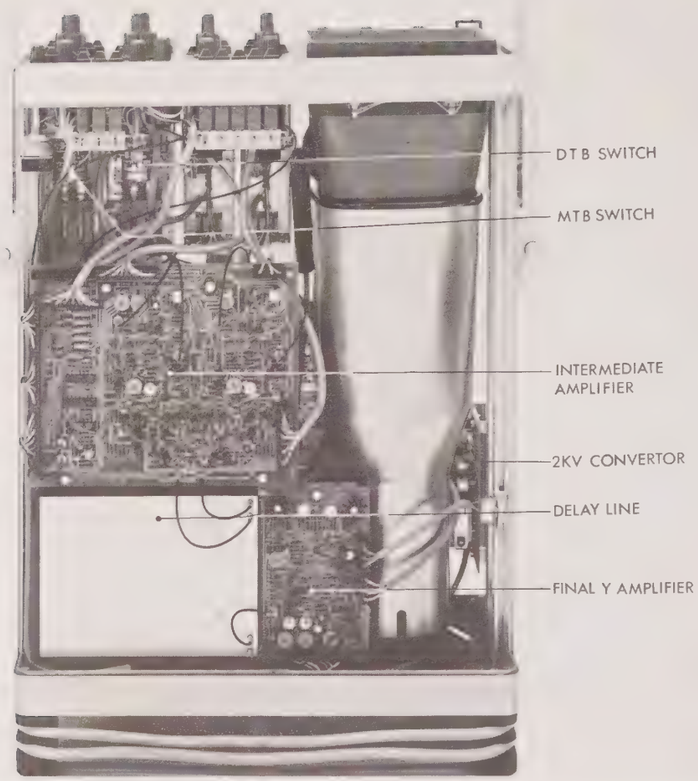


Fig. 3.2. Unit location, top view

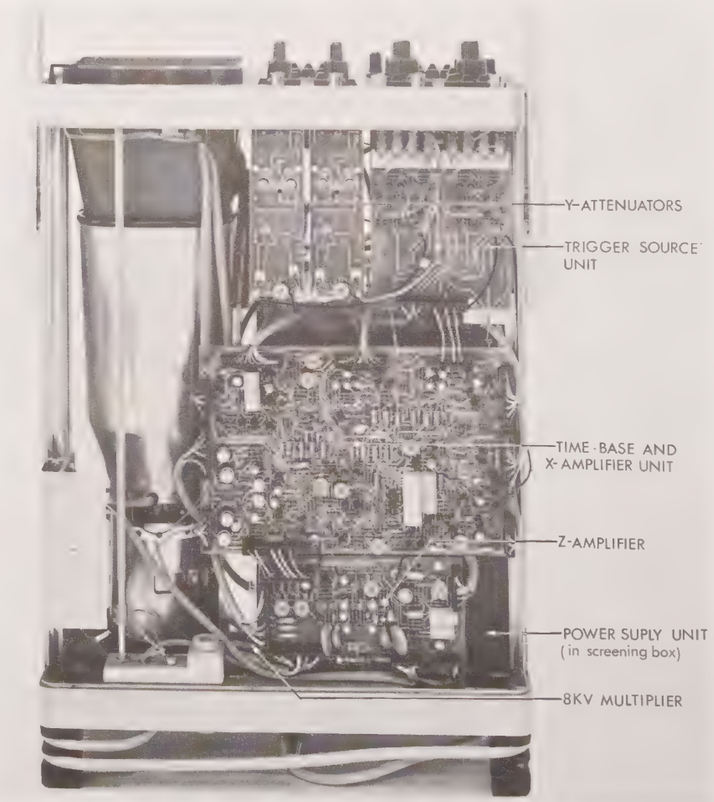


Fig. 3.3. Unit location, bottom view

3.3.5. Z Amplifier circuit board

This unit is the small rectangular printed-circuit board located on the underside, and towards the rear of the instrument.

For removal:
- unplug the five multipole connectors
- unsolder the two connections to the time-base
- unplug the coaxial connector to the intermediate amplifier
- remove the four retaining screws

3.3.6. Intermediate amplifier circuit board

This unit is located in mid-position adjacent to the c.r.t. on the upper side of the instrument.

For removal:
- unplug the seven multipole connectors
- unplug the six coaxial plugs on the board
- unplug two coaxial leads from the delay line
- remove the four retaining screws.

3.3.7. Final Y amplifier circuit board

This unit is a small rectangular printed-circuit board located on the upper side of the instrument towards the rear, adjacent to the gun assembly of the c.r.t.

For removal:
- unplug the three multipole connectors
- unplug the Y1 and Y2 connections from the c.r.t.
- unplug the two coaxial leads from the delay line
- remove the three retaining screws.

3.3.8. 2 kV Convertor

This unit is a small rectangular printed-circuit board rail-mounted on the under side of the instrument, adjacent to the base of the c.r.t. A metal housing gives protection against the high potentials developed in this circuit.

For removal:
- unscrew the metal protective housing
- unplug the multipole connectors
- unsolder the e.h.t. lead and remove from clip
- remove the two retaining screws from the rail-mounting.

For reassembly, the two securing nuts must be aligned in the rail. In the interests of safety, ensure that the protective housing is re-fitted.

3.3.9. 8 kV multiplier

This is a sealed unit located below the final Y amplifier circuit board adjacent to the c.r.t. gun.

For removal:
- discharge the c.r.t. post-acceleration anode and e.h.t. connector (see 3.3.1.) after disconnection from the c.r.t.
- unsolder the coaxial cable from the 2 kV convertor and remove from clip
- remove the delay-line and adjacent final Y amplifier
- spring the 8 kV unit retaining clips from the instrument frame (if necessary remove the power supply unit from the rear to obtain access to the retaining clips).

3.3.10. Power supply circuit board

This unit is a square printed-circuit board accessible from the rear of the instrument.

For removal:
- unscrew the rear cover plate of the instrument
- remove the two screws securing the circuit board to the rear panel
- unplug the five multipole connectors
- carefully withdraw the circuit board from its compartment.

3.3.11. Delay line

This unit is located on the upper side, at the rear of the instrument, adjacent to the final Y amplifier.

For removal:
- unplug the four miniature coaxial connectors
- remove the three screws securing the cover plate
- withdraw the delay line.

3.3.12. Cathode-ray tube

For removal:
- slacken the brace round the neck of the c.r.t. and remove all side connections carefully to avoid bending the pins
- disconnect and discharge the e.h.t. connector and c.r.t. anode as recommended in section 3.3.1.
- remove the two rear cover plate screws
- carefully remove the tube base
- unplug the multipole connector of the orthogonality and trace-rotation coils on the final Y amplifier
- slacken the upper plastic centring bracket at the front of the c.r.t.
- remove the bezel by pulling its lower ecge
- carefully withdraw the c.r.t. through the front panel of the instrument.

When fitting a c.r.t., the inside of the rubber sleeve should be sprinkled with industrial talc to facilitate insertion.

3.3.13. Pushbutton switches

Each of the pushbutton sets listed below is fitted to the front panel by means of clamping devices secured by hexagon screws:

- A/ALT/CHOP/ADD/B
- DEL'D TB/EXT X DEFL/MAIN TB
- AUTO/TRIG/SINGLE
- DC/LF/HG (main time-base)
- DC/LF/HF (delayed time-base)
- A/B/EXT/MAIN TB
- A/B/EXT/MAINS

To remove a pushbutton switch, the hexagon screws that secure it to the front panel must be removed. To replace one switch-section of a pushbutton set, refer to Fig. 3.5.

Before a pushbutton switch is refitted to the front panel, it is advisable to stick the two parts of the clamping device together by means of adhesive tape or non-hardening glue, in order to facilitate replacement, refer to Fig. 3.6.

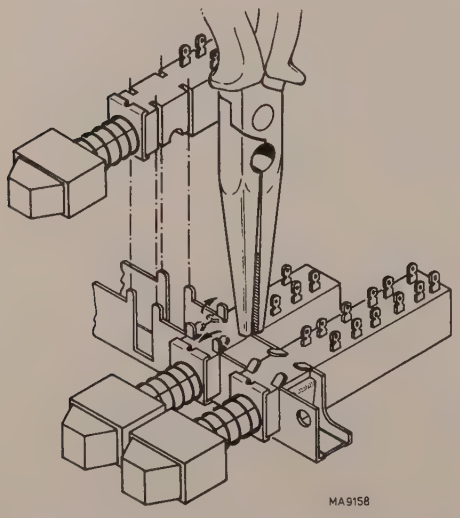


Fig. 3.5. Replacing a switch-segment of a push-button set

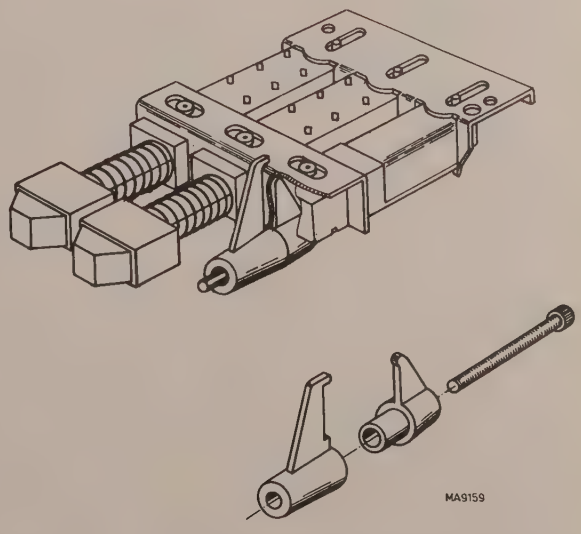


Fig. 3.6. Push-button set clamping device

3.3.14. Trigger source unit

This unit comprises the trigger source and trigger coupling pushbutton switches, integral with the printed-circuit board.

For removal:
- unplug the two multipole connectors
- unplug the two coaxial leads from the preamplifier
- unplug the opto-isolator coaxial lead from the time-base
- unsolder resistors R800 and R1000 from the time-base
- unsolder resistors R701 and R751 from the EXT sockets
- unsolder the earth connection from C762
- remove the retaining screw at the rear of the board
- remove the hexagonal front panel fixing screws as outlined in 3.3.13.

3.3.15. Attenuator unit

For removal:

- remove the appropriate AMPL knobs and the nut under these knobs
- unplug the multipole connector and the miniature coaxial plug on the circuit board of the preamplifier
- disconnect the earthing wire
- remove the two screws that secure the lower part of the attenuator unit to the front panel
- carefully lift the attenuator unit out of the oscilloscope.

3.3.16. Carrying handle

For removal:
- remove the upper and lower instrument cover plates
- remove the plastic strip which is snapped on to the grip by slight leverage under one edge
- remove the four hexagon screws which secure the grip to the brackets
- depress the pushbuttons in the brackets and turn the carrying handle vertically above the upper side of the oscilloscope
- keep the pushbutton of the right-hand bracket depressed and pull the bracket from its bearing
- remove the grip from the remaining bracket
- depress the pushbutton of the left-hand bracket and turn the latter vertically below the base of the instrument
- keep the pushbutton depressed and pull the bracket from its bearing.

3.3.17. Special tools

3.3.17.1. Special tool for the slotted nuts of attenuator switches

A tool can be made for this purpose as shown in Fig. 3.7. All dimensions are given in millimetres. The material is silver-steel N094, temepred 40-45 Rc. Service order code 5322 395 54023.

3.3.17.2. Special tool for the slotted nuts of the POSITION and LEVEL/SLOPE potentiometers

A tool can be made for this purpose as shown in Fig. 3.8. All dimensions are given in millimetres. The material is silver-steel N094, tempered 40-45 Rc. Service order code 5322 395 54024

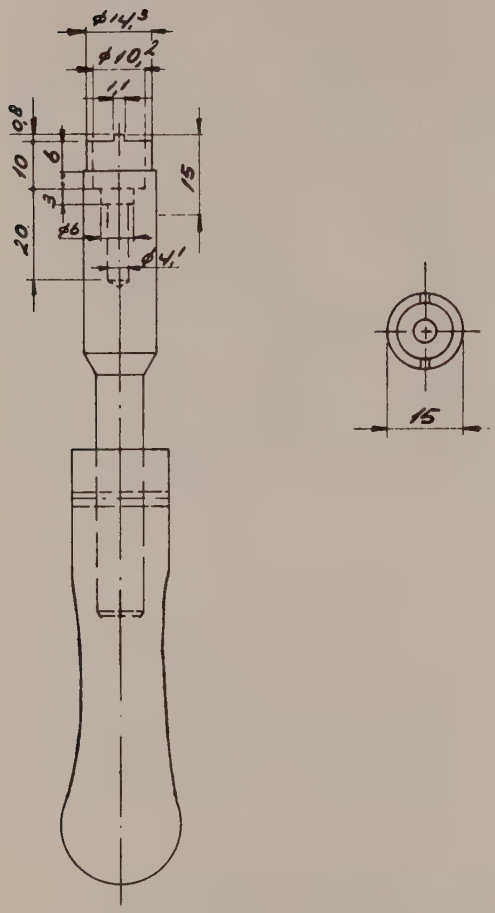


Fig. 3.7. Tool for attenuator switches

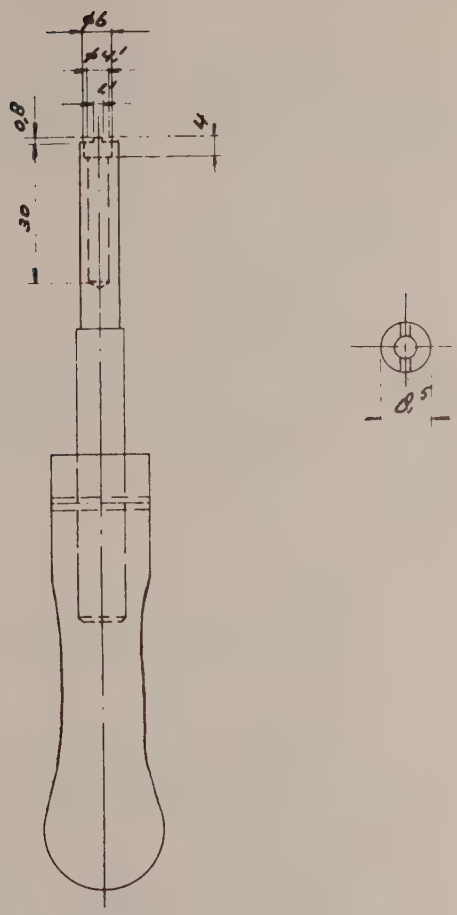


Fig. 3.8. Tool for Position and Level potentiometers

3.3.18. Soldering micro-miniature semi-conductors

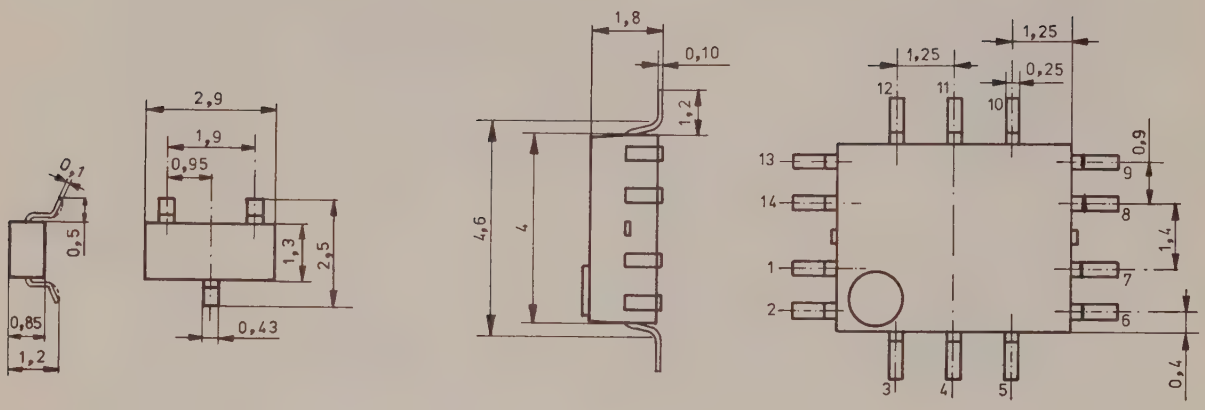


Fig. 3.9. Dimensional drawings SOT-23 and SOT-43

Because of the small dimensions of these SOT semi-conductors and the lack of space between the components on the printed-circuit board, it is necessary to use a miniature soldering iron with a pin-point tip (max. dia 1 mm) to solder a SOT on to a printed-circuit board.

Working method:

- Carefully unsolder one after the other the soldering tags of the semi-conductor.
- Remove all superfluous soldering material. Use a sucking iron or sucking copper litze wire.
- Check that the tags of the replacement part are clean and pre-tinned on the soldering places.
- Locate the replacement semi-conductor exactly on its place, and solder each tag to the relevant printed conductor on the circuit board.

NOTE: Bear in mind that the maximum permissible soldering time is 10 seconds during which the temperature of the tags must not exceed 250 deg C. The use of a solder with a low melting point is therefore recommended.

Take care not to damage the plastic encapsulation of the SOT23 and SOT43 during the soldering process (softening point of the plastic is 150 deg C).

Suitable soldering irons are:

- ORYX micro-miniature soldering instrument, type 6A, voltage 6 V, in combination with PLATO pin-point tip type 0-569.
- ERSA miniature soldering iron, type minor 040 B, voltage 6 V.

3.4. CHECKING AND ADJUSTING

Introduction

The following information provides the complete checking and adjusting procedure for the PM 3240 oscilloscope. As various control functions are interdependent, a certain order of adjustment is often necessary. The procedure is, therefore, presented in a sequence which is best suited to this order, cross-reference being made to any circuit which may affect a particular adjustment. Before any adjustment or check, the instrument must attain its normal operating temperature. Under average conditions this will be approximately 30 minutes after switching on.

All controls which are mentioned without item numbers are located on the front panel of the oscilloscope.

Recommended test equipment

Digital multimeter, e.g. PHILIPS type PM 2421 or PM 2422A.
Pulse generator, rise-time ⩽ 200 ns, e.g. PHILIPS type PM 5711 or PM 5775/6.
Pulse generator, rise-time ⩽ 1 ns, e.g. Tektronix type 106 or 284.
Constant amplitude signal generator, e.g. Tektronix type 191 or 067.0532.01.
R.C. Standardizer, 1 MOhm//15 pF, e.g. Tektronix type 067.0537.00.
Time-marker generator, e.g. Tektronix type 2901.

3.4.1. Performance check

3.4.1.1. Preliminary control settings

- Set the POWER switch to OFF.
- Connect the instrument to the mains.
- Depress the ALT button of the vertical display mode switch.
- Depress the MAIN TB button of horizontal deflection switch.
- Depress the AUTO button of the trigger mode switch.
- Set the MAIN TIME/DIV switch to .1 ms.
- Set the DEL'D TIME/DIV switch to OFF.
- Set the AMPL switches to .1 V/DIV.
- Set the TIME/DIV and AMPL potentiometers to CAL.
- Set the TB MAGN switch to x1 (push).
- Set the POSITION potentiometers to their mid-positions.
- Turn the INTENS potentiometer fully clockwise.
  Controls not mentioned may remain in any position. For subsequent tests, unless otherwise stated, controls should be left in the same position as in the previous check.
- Set the POWER switch to ON.
- Check that the POWER ON lamp lights up.
- Check that the two time-base lines appear on the screen.
- Check the working of the graticule illumination control.

3.4.1.2. Cathode-ray tube

- Set the INTENS and FOCUS controls for a sharp, well-defined trace.
- Centre both time-base lines, using the POSITION potentiometers.
- Check that the traces run exactly in parallel with the central horizontal graticule line; if necessary, readjust in accordance with section 3.4.2.2.5.

3.4.1.3. Vertical axes

Balance

- Depress the A button of the vertical-display mode switch.
- Depress the 0 button of the AC-0-DC switch.
- Switch the AMPL step attenuator between positions 5 mV/DIV and 10 mV/DIV.
- Check that the trace does not jump. If necessary, readjust the BAL potentiometer on the front panel.
- Repeat for the B channel.

Gain and pulse response

– Depress button A(B) of the horizontal-display mode switch and DC of the AC-0-DC switches.
– Depress the PULL TO INVERT switch incorporated in the channel B POSITION potentiometer.
– Set the AMPL step attenuator to 10 mV/DIV.
– Set the AMPL continuous controls to CAL position.
– Apply a square-wave signal with a maximum rise-time of 1 ns, a peak-to-peak value of exactly 60 mV and a frequency of 1 kHz to input socket A(B).
– Set the MAIN TB switch to a suitable position.
– Obtain a stationary trace with the aid of the LEVEL potentiometer.
– Check that the trace height is 6 divisions. If necessary, adjust the GAIN potentiometer on the front panel.
– Check that the pulse-top is straight within 0,1 DIV.
– Increase the frequency of the input signal successively to 10 kHz, 100 kHz and 1 MHz.
– Check that the pulse-top remains straight within 0,1 DIV. at these frequencies.
– Set the MAIN TIME/DIV switch to .05 μs.
– Pull the TB MAGN control to its x5 position.
– Adjust the LEVEL control for a stable display.
– Check that the rise-time between 10 % and 90 % of the pulse height is $\leqslant$ 7 ns.
– Push the TB MAGN control to its x1 position.

If the pulse response of both channels does not meet the requirements stated above, readjust the vertical amplifiers in accordance with section 3.4.2.3.

Bandwidth

– Depress the A button of the vertical-display mode switch.
– Set the AMPL vernier controls to CAL position.
– Set the AMPL switches of both channels to .1 V/DIV.
– Apply a sine-wave voltage of 800 mV_{p-p}, at 50 kHz to input socket A(B) (trace height 8 divisions).
– Increase the generator frequency to 50 MHz while retaining the amplitude of the input signal at 800 mV_{p-p}.
– Check that the trace height is at least 5,6 divisions.

Common-mode rejection

– Depress button ADD of the vertical-display mode switch.
– Pull the channel B PULL TO INVERT switch, incorporated in the POSITION potentiometer, in order to invert channel B signal.
– Set the AMPL switches to .1 V/DIV.
– Apply a sine-wave voltage simultaneously to sockets A and B.
– Check the rejection rate in accordance with the following table.

Note: Adjust the continuous AMPL control of channel A or channel B for minimum trace height.

Input voltage	Generator frequency	Max. trace height	Rejection factor
2,4 V	100 kHz	0,24 DIV	100
2,4 V	1 MHz	0,24 DIV	100

– Disconnect the input voltage.

Chopped mode

– Depress button CHOP of the vertical-display mode switch.
– Set the MAIN TIME/DIV switch to .2 μs.
– Check that there are two time-base lines displayed which can be shifted in relation to each other using the POSITION controls.

Alternate mode

– Depress the ALT pushbutton of the vertical-display mode switch.
– Set the MAIN TIME/DIV switch to 10 μs.
– Check that there are two time-base lines displayed which can be shifted in relation to each other using the POSITION controls.
– Set the MAIN TIME/DIV switch to .1 s.
– Check that the channels are switched over after every sweep of the sawtooth voltage.

Effective signal delay

– Set the MAIN TIME/DIV switch to .05 μs.
– Pull the TB MAGN control to x5.
– Set the channel A AMPL switch to .5 V.
– Apply a square-wave voltage of approximately 600 $mV_{p\text{-}p}$, repetition frequency approximately 100 kHz, rise-time $\leqslant$ 1 ns, to input socket A.
– Adjust the LEVEL potentiometer to obtain a stable, stationary display.
– Set the channel A AMPL switch to position .1 V.
– Turn the INTENS potentiometer to maximum intensity.
– Check that the effective delay time T is larger than 1 division, see fig. 3.10.

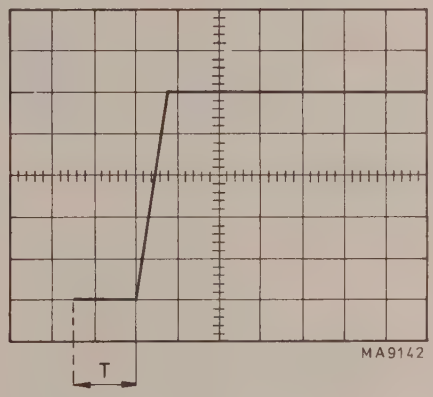


Fig. 3.10. Effective signal delay

Dynamic range and position range

– Set the AMPL switches to .1 V/Div.
– Set the AMPL vernier controls to CAL.
– Apply a sine-wave voltage of 2,4 V, frequency 15 MHz, to input socket A(B).
– Depress button A(B) of the vertical-display mode switch.
– Check that the top and bottom parts of the sinewave can be displayed.
– Check that the displayed sinewave shows no distortion over the whole POSITION range.

3.4.1.4. Main time-base generator

Trigger slope and level

– Depress button A of the vertical-display mode switch.
– Set the channel A AMPL switch to .2 V/DIV.
– Depress the AC button of the channel A AC-0-DC switch.
– Depress the DC button of the main time-base trigger frequency range switch.
– Apply a sinewave signal with an amplitude of 1,6 V to input socket A, frequency approximately 30 kHz.
– Set the MAIN TIME/DIV switch to such a position that a few cycles of the input sinewave are displayed.
– Push the SLOPE switch to its + position.
– Check that the time-base generator starts on the positive-going part of the sinewave and moves upwards when the LEVEL potentiometer is turned clockwise.
– Pull the SLOPE switch to its – position.

– Check that the time-base generator starts on the negative-going part of the sinewave.
– Set the AMPL switch to .1 V/DIV.
– Position the trace in such a way that the bottom half of the signal is displayed.
– Check that it is possible to shift the starting point of the sinewave over 16 divisions, by means of the LEVEL control.
– Push the SLOPE switch to its + position.
– Position the trace in such a way that the top half of the signal is displayed.
– Check that it is possible to shift the starting point of the sinewave over 16 divisions, by means of the LEVEL control.
– Check that the maximum control range of the LEVEL potentiometer does not exceed 32 divisions.

Trigger sensitivity

– Adjust the main time-base LEVEL potentiometer for a stationary display.
– Set the MAIN TIME/DIV switch to such a position that a reasonable number of sinewaves is written on the screen.
– Set the trigger sensitivity in accordance with the table below.

Input Signal	Frequency	Vertical-display mode	MTB trigger mode	MTB trigger frequency range	MTB trigger source	Trace Height/ Volts
YA (BU4)	20 Hz	A	TRIG	DC	A	0,5 div
	10 kHz					0,5 div
	50 MHz					0,5 div
	30 kHz			LF		0,5 div
	30 kHz			HF		1,5 div
	50 MHz					0,5 div
	50 MHz		AUTO			0,5 div
YB (BU5)	20 Hz	B	TRIG	DC	B	0,5 div
	50 MHz					0,5 div
EXT (BU8)	20 Hz		TRIG	DC	EXT	150 mV
	50 MHz					1000 mV

Single-sweep operation

– Set the AMPL switch to .2 V/DIV.
– Set the LEVEL control to mid-range.
– Set the MAIN TIME/DIV switch to .1 s.
– Apply a signal that gives a trace height of approximately 8 divisions to input socket YA.
– Depress the 0 button of the channel A AC-0-DC switch.
– Push the SINGLE button of the trigger-mode controls.
– Check that the NOT TRIG'D lamp lights up.
– Depress button AC of the channel A AC-0-DC switch.
– Check that the trace is written once and that the NOT TRIG'D lamp is extinguished at the start of the sweep.

Triggering at mains frequency

– Depress the AUTO button of the trigger-mode controls.
– Depress the HF button of the trigger frequency range switch.
– Set the MAIN TIME/DIV switch to 5 ms.
– Apply a sinewave signal at mains frequency to input socket A.
– Adjust the AMPL controls of channel A to obtain a trace height of 3 divisions (The triggered display is not stable).
– Depress the MAINS button of the trigger-source controls.
– Check that a stable display can be obtained by means of the LEVEL potentiometer.

Time coefficients

– Apply a time-marker signal to the YA input.
– Check the sweep times at each position of the MTB TIME/DIV switch (cont. control knob in CAL position). The centre 8 time-marker periods must coincide with the centre 8 divisions of the display.
– Check also with the TB MAGN knob in x5 position.

If the requirements stated above are not met, readjust the main time-base generator in accordance with section 3.4.2.5.1.

– Check that the control range of the TIME/DIV continuous control is 1:2,6 to 1:3,5.

3.4.1.5. Delayed time-base generator

Trigger slope and level

– Depress button DEL'D TB of the horizontal-deflection switch.
– Depress button A of the del'd time-base trigger-source controls.
– Set the channel A-AMPL switch to .2 V/DIV.
– Depress the AC button of the channel A AC-0-DC switch.
– Depress the DC button of the delayed time-base-trigger-coupling controls.
– Turn the DELAY TIME multiplier knob fully anti-clockwise.
– Set the MAIN TIME/DIV switch to 20 μs and the DEL'D TIME/DIV switch to 10 μs.
– Apply a sinewave signal with an amplitude of 1,6 V to input socket A, frequency approximately 30 kHz.
– Push the SLOPE switch of the delayed time-base generator to its + position.
– Check that the time-base generator starts on the positive-going part of the sinewave and shifts upwards when the LEVEL potentiometer is turned clockwise.
– Pull the SLOPE switch of the delayed time-base generator to its – position.
– Check that the time-base generator starts on the negative-going part of the sinewave.
– Set the AMPL switch to .1 V/DIV.
– Position the trace in such a way that the bottom half of the signal is displayed.
– Check that it is possible to shift the starting point of the sinewave over 16 divisions by means of the delayed time-base LEVEL control.
– Position the trace in such a way that the top half of the signal is displayed.
– Check that it is possible to shift the starting point of the sinewave over 16 divisions by means of the delayed time-base LEVEL control.
– Check that the maximum control range of the LEVEL potentiometer does not exceed 32 divisions.

Trigger sensitivity

– Depress button DEL'D TB of the horizontal-deflection controls.
– Set the delayed time-base LEVEL potentiometer to obtain a stationary display.
– Set the MAIN TIME/DIV switch one position lower (longer sweep time) than the DEL'D TIME/DIV switch.
– Adjust the DEL'D TIME/DIV switch to such a position that a reasonable number of sinewaves is written on the screen (not for 20 Hz).
– Check the trigger sensitivity in accordance with the table below.

Input signal	Frequency	Vertical-display mode	DTB trigger frequency range	DTB trigger source	Trace Height/Volts
YA (BU4)	20 Hz	A	DC	A	0,5 div
	10 kHz				0,5 div
	50 MHz				0,5 div
	30 kHz		LF		0,5 div
	30 kHz		HF		1,5 div
	50 MHz				0,5 div
YB (BU5)	20 Hz	B	DC	B	0,5 div
	50 MHz				0,5 div
EXT (BU7)	20 Hz		DC	EXT	150 mV
	50 MHz				1000 mV

Time coefficients

– Apply a time-marker signal to the YA input.
– Check the sweep times at each position of the DTB TIME/DIV switch (cont. control knob in CAL position), always keeping the MTB TIME/DIV knob one position lower than the DTB TIME/DIV knob.
The centre 8 time-marker periods must coincide with the centre 8 divisions of the display.
– If necessary, check also with the TB MAGN. knob in x5 position.

If the requirements stated above are not met, readjust the delayed time-base generator in accordance with section 3.4.2.5.3.

– Check that the control range of the TIME/DIV continuous control is 1:2,6 to 1:3,5.

Delay time multiplier

– Depress the MAIN TB button of the horizontal-deflection controls.
– Depress button MAIN TB of the delayed time-base trigger-source controls.
– Set the MAIN TIME/DIV switch to 1 ms and the DEL'D TIME/DIV switch to .1 ms.
– Apply a time-marker signal with a repetition time of 1 ms to input socket A.
– Adjust the LEVEL potentiometer of the main time-base generator for a stable, triggered display.
– Check that the intensity modulation of the delayed time-base is visible.
– Check that the starting point of the delayed time-base (beginning of the intensified portion) can be continuous shifted in relation to the main time-base by rotating the DELAY-TIME controls.
Do not take into account the first and last half-divisions of the trace.

3.4.1.6. X Deflection

X Deflection via channel A

– Depress button EXT X DEFL of the horizontal-deflection controls.
– Depress button A of the X deflection selector (m.t.b. trigger source).
– Set the channel A AMPL switch to .5 V/DIV.
– Depress button AC of the channel A AC-0-DC switch.
– Apply a sinewave signal of exactly 3 $V_{p\text{-}p}$, 2 kHz, to input socket A.
– Check that the trace width is approximately 6 divisions.

X Deflection via channel B

– Depress button A of the vertical display-mode switch.
– Set the channel B AMPL switch to .5 V/DIV.
– Depress button AC of the channel B AC-0-DC switch.
– Depress button B of the X deflection selector
– Apply a sinewave voltage of exactly 3 $V_{p\text{-}p}$, 2 kHz, to input socket B.
– Check that the trace width is approximately 6 divisions.

External X deflection

– Depress button EXT of the X deflection selector
– Apply a sinewave voltage of exactly 3 $V_{p\text{-}p}$, frequency approximately 10 kHz, to the EXT input socket.
– Check that the trace width is 6,5 to 10 divisions.

Bandwidth

– Adjust the amplitude of the input signal to obtain a trace width of 6 divisions.
– Increase the frequency of the input signal to 1 MHz.
– Check that the trace width is at least 4,2 divisions.

Phase difference

- Depress the A button of the vertical-display mode switch.
- Depress button EXT X DEFL of the horizontal-deflection controls.
- Set the AMPL switches to .1 mV/DIV.
- Depress button A of the X deflection selector.
- Depress the DC buttons of the AC-0-DC switches.
- Apply a sinewave voltage at a frequency of 10 kHz to input socket A.
- Check that a solid line, at an angle of 45° is displayed.
- Increase the frequency of the input signal to 100 kHz.
- Check that the phase error does not exceed 3°, see fig. 3.11. in which $\frac{B}{A}$ equals the sine of the phase error angle.

X deflection with internal mains voltage

- Depress button MAINS of the X deflection selector.
- Check that the trace width is 8 divisions, ±1,5 div.; If necessary, readjust in accordance with section 3.4.2.5.4.

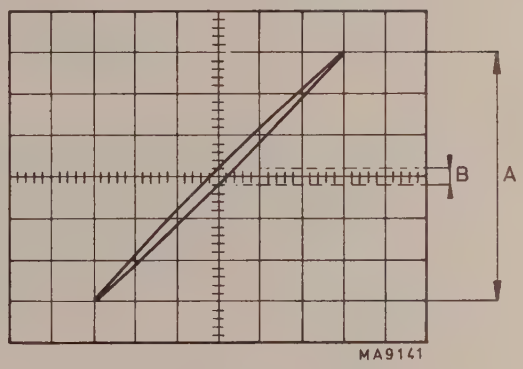


Fig. 3.11. Phase difference in X-Y mode.

3.4.1.7. Mains voltage fluctuations

- Depress button CHOP of the display-mode controls.
- Set the AMPL switches to .5 V/DIV.
- Set the MTB TIME/DIV and the LEVEL knob for a reasonable display.
- Depress buttons AC of the signal-coupling controls.
- Pull the TB MAGN switch to its x5 position.
- Interconnect the CAL sockets and the A and B input sockets.
- Check that neither the trace width nor the trace height changes when the mains voltage is varied between 90 V and 260 V. Also check that the trace brilliance does not change.

3.4.2. Adjusting procedure

3.4.2.1. Preliminary control settings

- Depress the PULL TO INVERT switch incorporated in the channel B.
- Set the POSITION potentiometers to their mid-positions.
- Depress buttons DC of the AC-0-DC switches.
- Rotate the DELAY TIME multiplier knob fully anti-clockwise.
- Depress button MAIN TB of the horizontal-deflection controls.
- Push the TB MAGN control to position x1.
- Depress buttons MAIN TB and AUTO of the trigger-mode controls.
- Set the MAIN TIME/DIV switch to 1 ms and the DEL'D TIME/DIV switch to OFF.
- Set the continuous TIME/DIV controls to CAL.
- Depress buttons DC of the trigger-coupling controls.
- Depress buttons A of the trigger-source controls.

If necessary, first check the power supply, refer to 3.4.2.7.

All adjustment points are indicated in Fig. 3.13 and 3.14.

3.4.2.2. Cathode-ray tube circuit

3.4.2.2.1. Trace rotation

- Depress button A of the vertical-display mode switch.
- Depress button MAIN TB of the horizontal-deflection controls.
- Centre the time-base line, using the POSITION controls.
- Check that the time-base line runs exactly parallel with the horizontal-lines of the graticule; if necessary, readjust TRACE ROT. potentiometer R684

3.4.2.2.2. Brilliance

- No vertical deflection.
- Depress button EXT X DEFL of the horizontal-deflection controls (no horizontal-deflection).
- Turn the INTENS potentiometer 90° from the left-hand stop.
- Check that the dot is barely visible. If necessary, readjust potentiometer R1327 136

3.4.2.2.3. Brilliance ratio

- Depress button A of the vertical-display mode switch.
- Depress button MAIN TB of the horizontal-deflection controls.
- Turn the DELAY TIME control to its mid-position.
- Set the MAIN TIME/DIV switch to 1 ms and the DEL'D TIME/DIV switch to .2 ms.
- Set the INTENS potentiometer to a position 180° from its anti-clockwise stop.
- Check that the trace of the main time-base generator is just visible over the entire screen and that the portion determined by the delayed time-base generator is brighter. If necessary, readjust the INTENS RATIO potentiometer R1115 133

3.4.2.2.4. Focus and astigmatism

- Depress button A of the vertical-display mode switch.
- Depress button MAIN TB of the horizontal-deflection controls.
- Set the delayed time-base TIME/DIV switch to OFF.
- Apply a sinewave signal at a frequency of 10 kHz to input socket A.
- Adjust the trace height to 6 divisions, using the AMPL switch and vernier.
- Set the MAIN TIME/DIV switch and the LEVEL potentiometer to such a position that several complete cycles are displayed.
- Set the INTENS potentiometer for normal brilliance.
- Check that a reasonably sharp trace can be obtained with the aid of the FOCUS potentiometer. If necessary, readjust astigmatism potentiometer R1344

3.4.2.2.5. Geometry

- Depress button A of the vertical-display mode switch.
- Depress button MAIN TB of the horizontal-deflection controls.
- Set the DEL'D TIME/DIV switch to OFF.
- Apply a sinewave voltage of 12 $V_{p\text{-}p}$, frequency approximately 10 kHz to input socket A.
- Set the channel A AMPL switch to .1 V/DIV.
- Set the MAIN TIME/DIV switch to .2 ms.
- Check that the displayed vertical lines are straight; if necessary, readjust potentiometer R1346

3.4.2.3. Vertical deflection

3.4.2.3.1. Gain - Channel A

- Depress button A of the vertical-display mode switch.
- Set the AMPL switch to .5 V/DIV.
- Set the AMPL cont. control to CAL.
- Depress button DC of the AC-0-DC switch.
- Apply a square-wave voltage with an amplitude of exactly 3 V to input socket A, frequency approximately 2 kHz.
- Check that trace height is exactly 6 divisions; if necessary, readjust the GAIN preset-potentiometer on the front panel.

– After adjustment, the GAIN preset-potentiometer on the front panel should occupy its mid-position. If necessary, readjust potentiometer R641. (If the setting cannot be reached with R641, change R645.)
– Check that the control range of the AMPL cont. control is at least 1:2,6 to 1:3,5.

3.4.2.3.2. DC Balance - Channel A

– Centre the time-base line, using the POSITION control.
– Check that the time-base line does not jump when the AMPL step attenuator is switched; if necessary, readjust the BAL preset-potentiometer on the front panel.
– Check that the trace does not move if the AMPL continuous control is turned; if necessary readjust R128(A)

3.4.2.3.3. Gain - Channel B

– Depress button B of the vertical-display mode switch.
– Set the AMPL switch to .5 V/DIV.
– Set the AMPL cont. control to CAL.
– Depress button DC of the AC-0-DC switch.
– Apply a square-wave voltage with an amplitude of exactly 3 V to input socket B, frequency approximately 2 kHz.
– Check that the trace height is exactly 6 divisions; if necessary, readjust the GAIN preset-potentiometer on the front panel.
– Check that the control range of the AMPL cont. control is at least 1:2,6 to 1:3,5.

3.4.2.3.4. DC Balance - Channel B

– Centre the time-base line, using the POSITION control.
– Check that the time-base line does not jump when the AMPL step attenuator is switched; if necessary, readjust the BAL preset-potentiometer on the front panel.
– Check that the trace does not move if the AMPL cont. control is turned; if necessary, readjust R128(B)

3.4.2.3.5. Polarity balance - Channel B

– Check that the trace does not jump when the PULL TO INVERT switch, incorporated in the channel B POSITION potentiometer is operated; if necessary, readjust potentiometer R435

3.4.2.3.6. Input attenuators

The input attenuators of both channels are identical. Therefore, only one procedure has been described.

Attenuator - Channel A(B)

– Depress button A(B) of the vertical-display mode switch.
– Set the MAIN TIME/DIV switch to 20 μs.
– Depress button DC of the AC-0-DC switch.
– Apply a square-wave signal, frequency approximately 20 kHz, rise-time $\leqslant$ 200 ns and amplitude as indicated in the table below, to input socket A(B).
– Check that the displayed square-wave is free from overshoot and rounding.

AMPL/DIV switch	Input signal on A(B)	Adjustment	Trace height
5 mV	30 mV	C108	6 div. ±2 %
10 mV	60 mV		6 div. ±2 %
20 mV	120 mV		6 div. ±2 %
50 mV	300 mV	C101	6 div. ±2 %
100 mV	600 mV		6 div. ±2 %
200 mV	1,2 mV		6 div. ±2 %
500 mV	3 V	C109	6 div. ±2 %
1 V	6 V		6 div. ±2 %
2 V	12 V		6 div. ±2 %

Maximum admissible pulse-top error: 2 %.

Input impedance - Channel A(B)

– Apply the voltages mentioned in the table above via an input RC Standardizer of 1 MOhm//15 pF to input socket A(B).
– Check that the displayed square-wave is free of rounding and overshoot; maximum admissible pulse-top error: 2 %; if necessary, readjust in accordance with table below.

AMPL/DIV switch	Standardizer Input	Adjustment	Trace Height
5 mV	30 mV	C107	3 div. ±2 %
10 mV	60 mV		3 div. ±2 %
20 mV	120 mV		3 div. ±2 %
50 mV	300 mV	C102	3 div. ±2 %
100 mV	600 mV		3 div. ±2 %
200 mV	1,2 mV		3 div. ±2 %
500 mV	3 V	C111	3 div. ±2 %
1 V	6 V		3 div. ±2 %
2 V	12 V		3 div. ±2 %

3.4.2.3.7. Square-wave response - Channel B

– Depress button B of the vertical-display mode switch.
– Set the B AMPL switch to 20 mV/DIV.
– Depress the PULL TO INVERT switch incorporated in the channel B POSITION control.
– Set the MAIN TIME/DIV switch to .05 μs.
– Apply a square-wave voltage of approximately 120 $mV_{p\text{-}p}$, rise-time $\leqslant$ 1 ns, repetition frequency approximately 100 kHz.
– Check that the pulse-top is as straight as possible; maximum pulse-top error including ringing and overshoot 0,1 div.

Adjustments

C416 - R442
C603 - R619
C402
C606 - R621
R622
R445

– Also check the square-wave response in positions .1 V (input voltage 600 mV) and .5 V (input voltage 3 V) of the AMPL switch.
– Check also the square-wave response in the PULL TO INVERT B position.

3.4.2.3.8. Square-wave response - Channel A

– Depress button A of the vertical-display mode switch.
– Set the AMPL switch to 20 mV/DIV.
– Apply a square-wave voltage of approximately 120 mV_{p-p}, rise-time $\leqslant$ 1 ns, repetition frequency approximately 100 kHz, to input socket A.
– Check that the pulse-top is as straight as possible; maximum pulse-top error including ringing and overshoot should not exceed 0,1 div.

Adjustments

C316. R432
C301
R345

– Check the square-wave response in positions .1 V (input voltage 600 mV) and .5 V (input voltage 3 V) of the AMPL switch.

3.4.2.4. Triggering

3.4.2.4.1. MAIN TB trigger level and DC balance of X amplifier

– Depress button A of the vertical-display mode switch.
– Depress button MAIN TB of the horizontal-deflection controls.
– Depress button AUTO of the trigger-mode controls.
– Set the MAIN TIME/DIV switch to .5 ms.
– Depress button MAIN TB of the DEL'D TB trigger-source controls.
– Depress button A of the main time-base trigger-source controls.
– Push the TB MAGN switch to position x1.
– Set the X POSITION potentiometer to such a position that the time-base line starts at the extreme left-hand line of the traticule.
– Depress button EXT X DEFL of the horizontal-deflection controls and button EXT of the main time-base trigger-source controls.
– Check that the dot is in the centre of the screen; maximum deviation: 2 divs.
– Centre the dot by means of the X POSITION potentiometer.
– Depress button B of the main time-base trigger-source controls.
– Check that the dot is in the centre of the screen; if necessary, readjust potentiometer R451
– Depress button A of the main time-base trigger-source controls.
– Check that the dot is in the middle of the screen; if necessary, readjust potentiometer R351

3.4.2.5. Horizontal deflection

3.4.2.5.1. Main time-base

Stability

– Depress both 0 buttons of the AC-0-DC switches.
– Depress button MAIN TB of the horizontal-deflection controls.
– Depress button TRIG of the trigger-mode controls.
– Set the DEL'D TIME/DIV switch to OFF.
– Rotate the main time-base LEVEL control fully anti-clockwise.
– Turn STAB potentiometer R873 fully anti-clockwise.
– Check that there is a time-base line written.
– Rotate STAB potentiometer R873 approximately 20^{o} past the point where the time-base line ceases to be displayed.
– Depress button AUTO of the trigger-mode controls.
– Check that there is a time-base line written again.

Time coefficients

As the power supply may affect the sweep times, it must be checked before readjusting the sweep times, refer to 3.4.2.7.

- Depress button A of the vertical-display mode switch.
- Set the AMPL switch to .1 V/DIV.
- Depress button DC of the AC-0-DC switch.
- Depress button MAIN TB of the horizontal-deflection controls.
- Push the TB MAGN switch to position x1.
- Depress button AUTO of the trigger-mode controls
- Set the MAIN TIME/DIV vernier control to CAL.
- Depress button DC of the trigger-coupling controls.
- Depress button A of the trigger-source controls.
- Apply a time-marker signal at a repetition rate of 1 ms to input socket A, amplitude approximately 600 mV.
- Check that the 8 centre periods cover exactly 8 divisions; if necessary, readjust potentiometer R1223
- Pull the TB MAGN switch to position x5.
- Set the time-marker generator to 200 μs.
- Check that the 8 centre cycles cover exactly 8 divisions; if necessary, readjust potentiometer R1209
- Push the TB MAGN control to position x1.
- Set the MAIN TIME/DIV switch to 10 ms.
- Set the time-marker generator to 10 ms.
- Check that the 8 centre cycles cover exactly 8 divisions; if necessary, readjust potentiometer R914
- Check that the control range of the TIME/DIV continuous control is 1:2,6 to 1:3,5.
- Check the remaining positions of the TIME/DIV switch; the centre 8 periods should always cover exactly 8 divisions, ±2,5 %. On the end positions .5 s, .2 s, .1 μs and .05 μs the tolerance is ±3,5 %.
- Also check that the length of the time-base line always exceeds 10 divisions.

3.4.2.5.2. Linearity and horizontal positioning

- Set the MAIN TIME/DIV control to .05 μs.
- Pull the TB MAGN switch to its x5 position.
- Apply a time-marker signal with a pulse repetition frequency of .01 μs to input socket A.
- Check that the 8 centre cycles cover exactly 8 divisions.
- Check also that for the 8 centre cycles a display of 1 cycle/division is obtained; if necessary, readjust trimmer capacitors C1203 and C1208.
- Check that all other cycles have a width of 1 division by shifting the whole train of pulses across the screen. Do not take into account the first and last five cycles.
- Also check that with the X POSITION potentiometer fully anti-clockwise and fully clockwise the beginning and the end of the trace is written within the measuring graticule.

3.4.2.5.3. Delayed time-base

Stability

- Depress button DEL'D TB of the horizontal-deflection controls.
- Depress button A of the delayed time-base trigger-source controls.
- Depress button 0 of the channel A AC-0-DC switches.
- Set the MAIN TIME/DIV switch to .5 ms.
- Set the DEL'D TIME/DIV switch to .2 ms.
- Turn the delayed time-base LEVEL control fully anti-clockwise.
- Turn STAB potentiometer R1064 fully clockwise.
- Check that a time-base line is displayed.
- Rotate STAB potentiometer R1064 approximately 20° beyond the point where the time-base line ceases to be displayed.
- Depress button MAIN TB of the delayed time-base trigger-source controls.
- Check that the time-base line is displayed again.

Time coefficients

- Depress button A of the vertical-display mode switch.
- Set the AMPL switch to .1 V/DIV.
- Depress button DC of the AC-0-DC switch.
- Rotate the DELAY TIME control fully anti-clockwise.
- Depress button DEL'D TB of the horizontal-deflection controls.
- Depress button AUTO of the main time-base trigger-mode controls.
- Depress button A of the delayed time-base trigger-source controls.
- Set the TIME/DIV continuous controls to the CAL positions.
- Apply a time-marker signal at a repetition rate of 1 ms and an amplitude of approximately 600 mV to input socket A.
- Check that the 8 centre periods cover exactly 8 divisions; if necessary, readjust potentiometer R1097
- Check that the control range of the delayed time-base TIME/DIV contin. control is 1:2,6 to 1:3,5.
- Check the remaining positions of the DEL'D TIME/DIV switch.
  Keep the DELAY TIME control fully anti-clockwise during this check, and the MAIN TIME/DIV switch one position lower than the DEL'D TIME/DIV switch. In this way, the delayed time-base can complete an entire sweep.
- Check that the 8 centre periods always cover 8 divisions, ±2,5 % except in the positions .1 μs and .05 μs, where the tolerance is ±3,5 %.
- Check that in all positions of the DEL'D TIME/DIV switch the length of the time-base line exceeds 10 divisions.
- Check that no time-base line is written when the DEL'D TIME/DIV switch occupies the OFF position.

Delay time

- Depress button A of the vertical-display mode switch.
- Depress button DC of the AC-0-DC switches.
- Depress button MAIN TB of the horizontal-deflection controls.
- Depress button AUTO and MAIN TB of the trigger-mode controls.
- Set the DEL'D TIME/DIV switch to 1 μs.
- Set the MAIN TIME/DIV switch to 1 ms.
- Depress button DC of the trigger-coupling controls.
- Depress button A of the trigger-source controls.
- Rotate the TIME/DIV cont. controls to CAL.
- Apply a time-marker signal at a repetition rate of 1 ms.
- Set the LEVEL control of the main time-base for a triggered display.
- Check that the intensity modulation by the delayed time-base is visible over the entire range of the INTENS potentiometer.
- Check that the starting point of the delayed time-base can be continuously shifted along the main time-base line with the aid of the DELAY TIME control. Ignore the first and last half-divisions.

3.4.2.5.4. X Deflection with the mains signal

- Depress button EXT X DEFL of the horizontal-deflection controls.
- Depress button MAINS of the X deflection-source controls.
- Check that the trace width is 10 divisions, ±1 div.; if necessary; readjust potentiometer R1841

3.4.2.6. Calibration unit

- Check the calibration voltage for irregulaties.
- Check that the amplitude of the square-wave voltage is 3 $V_{p\text{-}p}$, ±0.7 %; if necessary, readjust R1906.
- Check that the frequency is 2 kHz ±2 %.
- Check that the CAL current is 6 mA ±1 %.

3.4.2.7. Power supply

Warning: Use an isolating mains transformer when working in the power supply unit. Bear in mind that the main part of this unit is connected direct to the mains. As it is preferred to check the proper function of the power supply with adjustable mains voltage, use of a variable transformer (insulated version) is recommended.

Attention: The power supply unit is provided with a pre-set potentiometer R1834 which controls the d.c. output of the circuit. DO NOT READJUST THIS POTENTIOMETER UNLESS IT IS STRICTLY NECESSARY.
A consequence of readjusting this potentiometer is that all d.c. output voltages change, so that several circuits of the oscilloscope (e.g. time base sweep) must be recalibrated.
In the factory this potentiometer has been adjusted to the nominal value of the +45 V output. This voltage must be +45 V, + or −100 mV.

General

The best way to check the power supply is, when this unit is connected to the normal circuitry of the PM 3240. Provisions have been taken that the unit, after being taken out, remains connected to the instrument.
To facilitate the removal, first disconnect the various connections of the power supply unit.
The supply currents can be measured on each contact of the power supply output connectors. To disconnect one contact of a connector carefully press (twice) the spring at the side of the contact and lift the contact out. Inserting an additional contact provided with a piece of extension wire simplifies current measurement. After replacing the original contact check the spring locking-action to prevent the contact from coming loose later-on.

When the power supply unit is overloaded, the current limitation is actuated. As a result of this, the power supply goes in the "hiccup" mode (2 seconds cycle time approx.). This is caused by, successively, slow charging of the capacitor C1809, starting of the chopper, activation of current limiting transistor TS1808, discharging of the regulator circuit capacitor and so on.
Another reason for the power supply going in the "hiccup" mode is, when the switching transistor TS1807 gets no base current from the regulator circuit. In this case capacitor C1809 is slowly charged until the chopper circuit starts which causes the discharge of the capacitor in a short time, and so on.
If necessary, the power supply unit only, can be checked with the aid of a dummy load, consisting of load resistors and capacitors, see Fig. 3.41.
If a fault is suspected in the power supply, the following procedure may help you to find what is wrong.

NOTE: The power supply must always be loaded with the nominal load.

Required instruments

- Variable mains transformer with isolated windings (e.g. Philips bench model 2422 529 00005 or panel model 2422 529 00006; input 220 V, output 0-248 V/3 A).
- Watt meter (to measure mains power input).
- Oscilloscope (5 MHz bandwidth).
- Resistor 100 Ω, 25 W (5322 115 50015).
- Resistor 22 Ω, 25 W (5322 115 50006).
- Resistor of 1 kΩ and 50 kΩ, 0,5 W.

Checking procedure

In the first part of this procedure the current gain of the switching regulator transistor is checked (and the value of the base resistor R1817).
Then the power supply circuit is checked while the regulating circuit is out of service (switching regulator transistor short-circuited). In this case always check that the voltage across C1809 never exceeds the sum of the voltages across GR1806 and GR1807.
Next the regulating circuit and current limitation is checked.

Proceed as follows:

- Connect the isolating/variable transformer to the mains.
- Connect the power supply unit in series with a 22 ohm, 25 W resistor and via a Watt-meter to the isolating/variable transformer.
- Remove current sensing transistor TS1808.
- Set the variable transformer to 0 volt.
- Switch on the oscilloscope and increase the variable transformer output until the voltage on the power supply reaches 40 V.
- Check that the voltage over C1809 amounts to approx. 56 V (the chopper circuit is not oscillating).

– If this voltage across C1809 does not appear, check the ripple eliminator circuit (TS1801 and TS1802), R1819 and check the chopper circuit on short-circuit.
– Switch-off the instrument.
– After the voltage across C1809 has completely disappeared, switch-on again and check that the voltage across C1809 is present again after approx. 2 seconds.
(The speed of charging depends on the current gain of TS1807 and the value of R1817).

R1817

– Increase the power supply input voltage until the voltage across C1809 amounts to 90 V.
– Connect a 1 kohm (0,5 W) resistor in parallel to C1809.
– The voltage across C1809 must now be 4 V; if not change R1817.
The value of R1817 must be between 25 k ohm - 56 k ohm.
If by changing R1817 the 4 V cannot be reached, TS1807 must be selected.
– Remove the 1 k ohm resistor.

– Adjust the mains input voltage to 40 V.
– Short-circuit emittor-collector of TS1807.
– Start the chopper circuit (TS1804, TS1806) by connecting for a short moment the base of TS1804 via a 50 k ohm (0,5 W) resistor to point 4 of transformer T1802.
– Check the voltage on point 5 of T1802. This must be a square wave of approx. 70 $V_{p\text{-}p}$, frequency approx. 18 kHz.
– The voltage over the 22 ohm series resistor in the mains input must be approx. 1,5 V.
– If the chopper does not oscillate, check the chopper circuit itself.
If the chopper goes in the "hiccup" mode when the 50 k ohm resistor remains connected, check the d.c. output circuits and the circuit connected to points 7 and 8 of T1802.
– Remove the 22 ohm resistor in the mains input.
– Increase the mains input voltage until the voltage over C1809 amounts to 100 V (not higher, otherwise the Z-diodes GR1806 and GR1807 will blow up).
The chopper must start automatically.
– Check the pulse on the base of TS1807.
Adjust with the variable transformer the voltage across C1809 to 90 V; check that this pulse can be varied with R1834. If not check the regulator circuit.
– The power consumption must be 25 W approx.
– Remove the short-circuit across TS1807; check that the pulse on the base of TS1807 changes at this moment.

– Fit current sensing transistor TS1808.
– Check that the chopper circuit cuts out (goes in the "hiccup" mode) when the load of the power supply is increased by approx. 50 %. To this end connect a 200 ohm 25 W resistor to the +45 V output. The current limitation goes "on" when the power output exceeds 30-35 W.
Also when the +45 V output is short-circuited, the power supply goes in the "hiccup" mode.

– Adjust the mains input voltage with the variable transformer to the nominal local voltage.
– If necessary adjust the +45 V output voltage (+ or –100 mV is allowed) with the aid of R1834
– Check again the voltage on point 5 of T1802 with an oscilloscope. The frequency must be 18-22 kHz; check the shape of the chopper voltage (150 $V_{p\text{-}p}$).
– Vary the mains voltage between 90 and 248 V.
Check that the +45 V output remains constant (between + or –200 mV).
Check the 50 % overload current limitation at 248 V.

WAVEFORMS IN THE POWER SUPPLY UNIT Fig. 3.12.

(Photographs taken from storage oscilloscope PM 3251)

1. Mains ripple eliminator (TS 1801)

a. A.C. Voltage on the emitter of TS1801
b. A.C. Voltage on the collector of TS1801.
Both voltages are measured with respect to the negative pole of electrolytic capacitor C1806.
Mains voltage 220 V.
PM 3251 settings: 5 V/DIV; 5 ms/DIV; external triggering from the mains.

2. Regulator input voltage versus voltage across switching transistor TS1807

a. Voltage on p3 with respect to p2 of IC1801
b. Collector-emitter voltage of TS1801; lower line is 0 V
Mains voltage 220 V
PM 3251 settings: 200 mV/DIV for a; 100 V/DIV for b;
20 ms/DIV; external triggering from p5T1802.

3. Chopper

a. Voltage between p2 and p3 of transformer T1801
b. Voltage between p7 and p8 of transformer T1802
Mains voltage 220 V
PM 3251 settings: 5 V/DIV; 10 μs/DIV; external triggering from p5T1802.

4. Switching transistor TS1801

Current flowing through R1802

a. Mains voltage 110 V
b. Mains voltage 220 V
PM 3251 settings: 0.5 V/DIV (= 0.25 A/DIV); 20 μs/DIV; external triggering from p5T1802.

5. Regulator input voltage at 220 V and 110 V mains voltage

Voltage on p3 with respect to p2 of IC1801
a. at 220 V
b. at 110 V
PM 3251 settings: 200 mV/DIV; 20 ms/DIV; external triggering from p5T1802.

6. Switching-on period

a. Voltage across R1802
b. Voltage on p8 of IC1801 with respect to p1 and p10
Lower line is 0 V
Mains voltage 220 V
PM 3251 settings: 5 ms/DIV; 200 mV/DIV for a; 1 V/DIV for b; external triggering from p5T1802; single shot.

7. Switching-on period

As photograph 6a, but with PM 3251 setting of 50 ms/DIV.

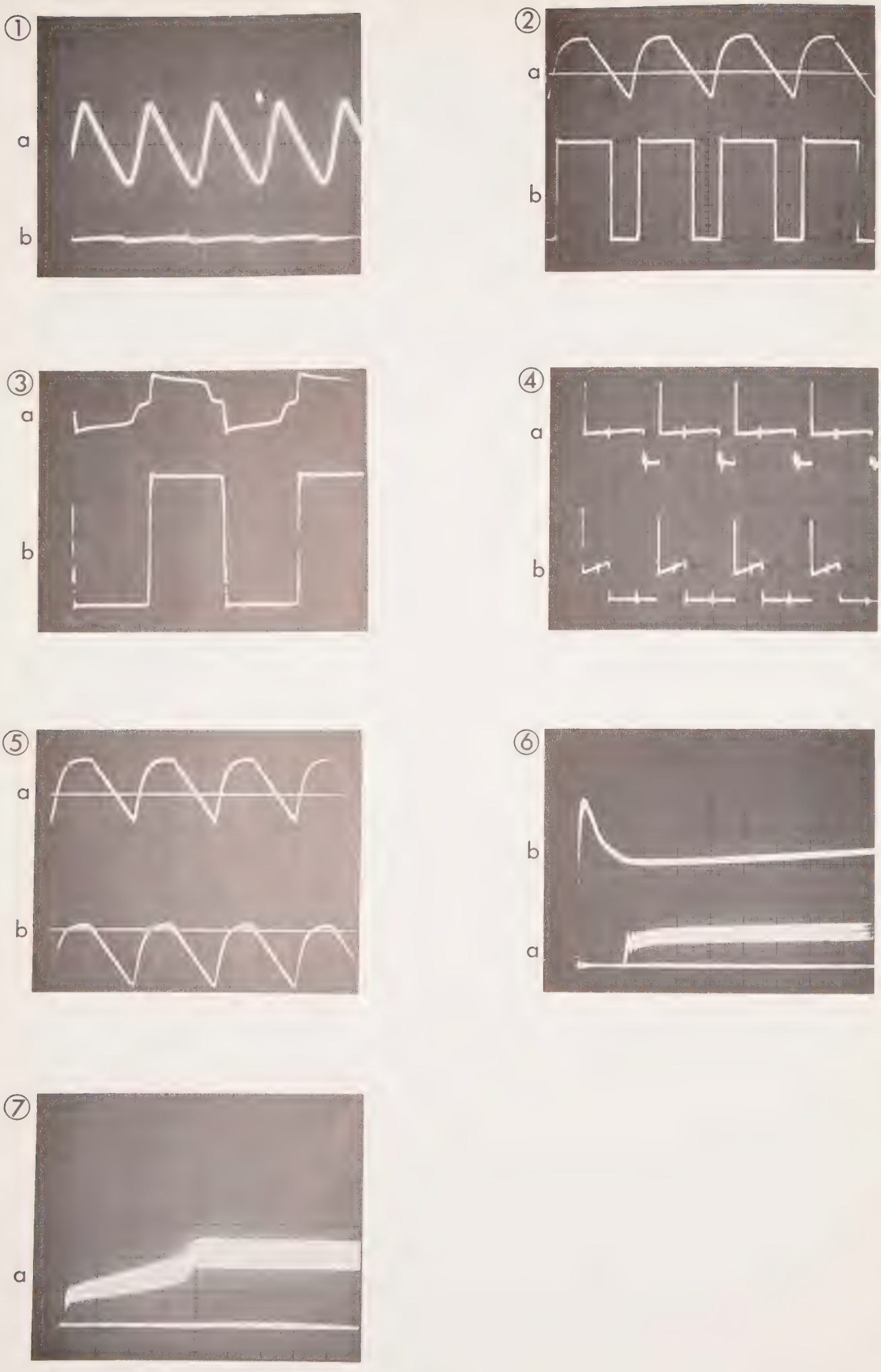


Fig. 3.12. Waveforms in the power-supply unit

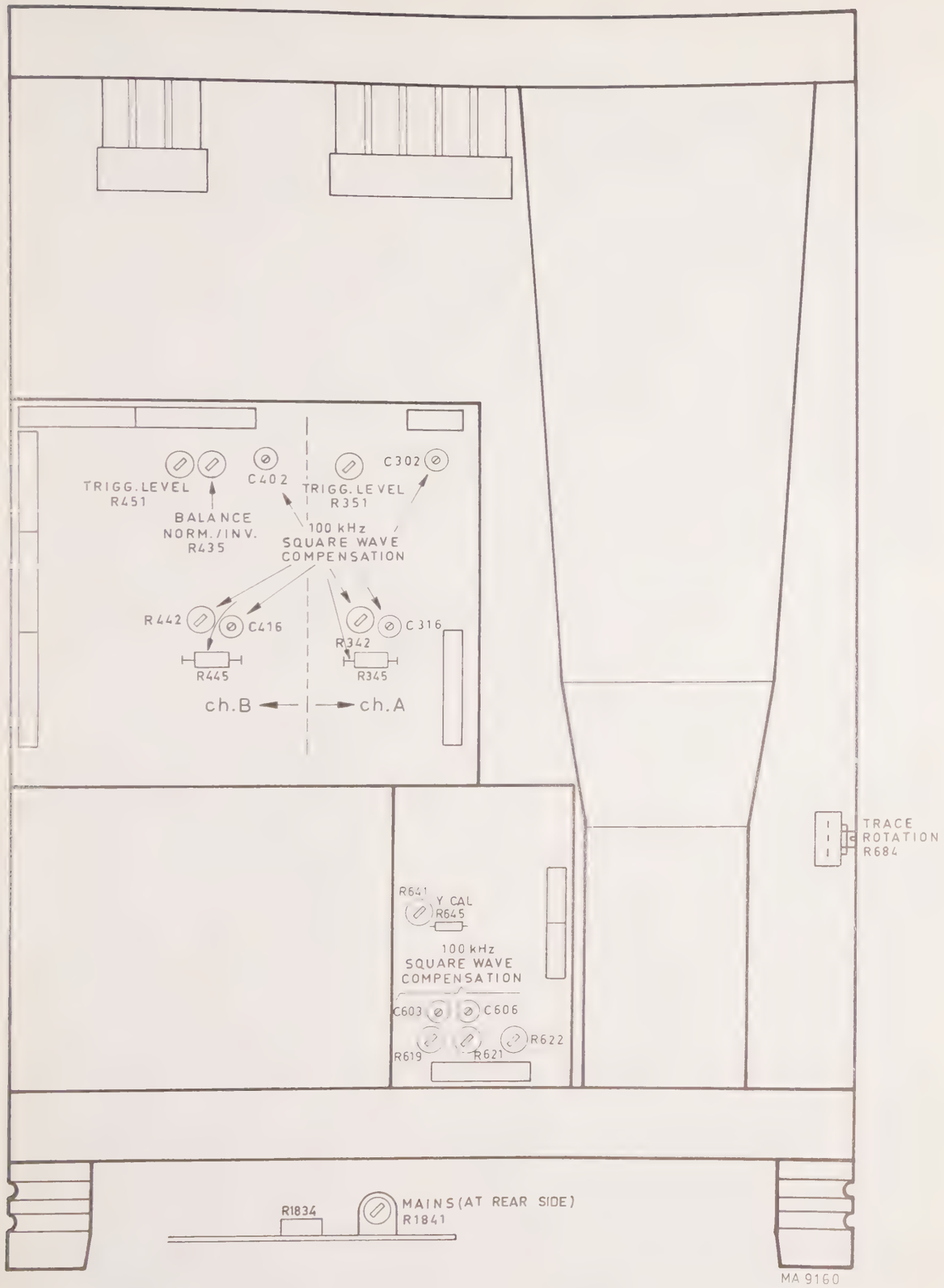


Fig. 3.13. Adjustments points, top view

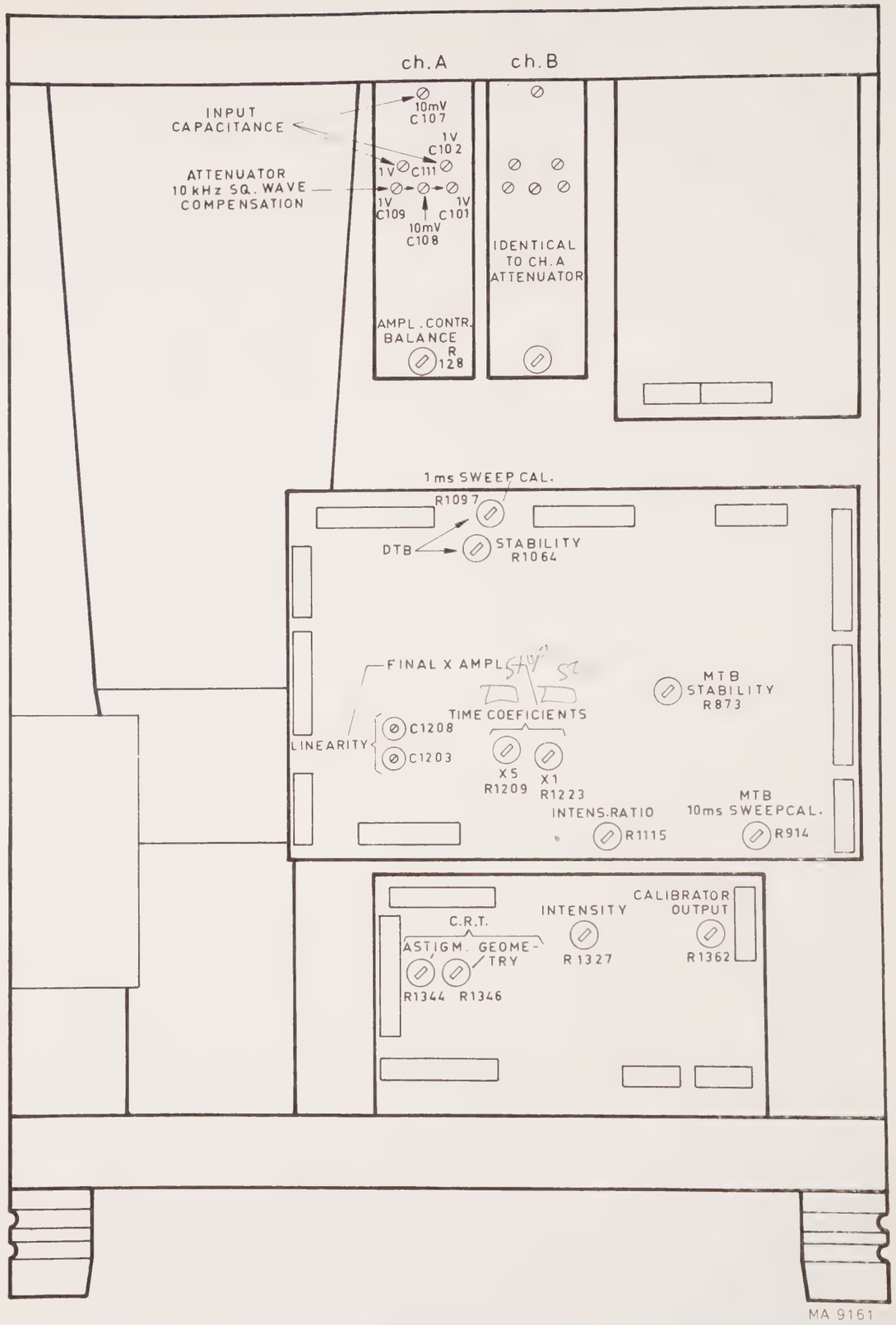


Fig. 3.14. Adjustment points, bottom view

3.5. TEST AND REPAIR HINTS

3.5.1. General information

- Use an isolating transformer when measurements must be made in the power supply.
- For measuring on the printed-wiring boards, test-pins with sharp points must be used. Be careful not to cause a short-circuit by letting the test-pin slip from the test point.
- Use an appropriate soldering iron and solder with a low melting point, if micro-miniature semi-conductors must be replaced it is essential to earth the tip of the soldering iron to the mass of the oscilloscope.
- Be very careful not to bend the pins on the neck of the c.r.t., since this is likely to result in a gas-leak.
- Do not remove any transistor, when the oscilloscope is switched-on.
- Do not plug and unplug connectors when the instrument is switched on.
- Do not touch any trim potentiometers or trimmers before a fault has been located.
- If internal coaxial cables have been taken loose, take care not to make earth-short-circuit if the connector might slip over the p.c. board.
- If the H.T. plug of the c.r.t. is taken loose, carefully discharge both the H.T. cable and the H.T. connection of the c.r.t. for at least several seconds, to avoid the risk of electrical shocks.

3.5.2. Y-amplifier

If there is a fault in one of the Y channels, it can easily be traced to a certain unit by combining the attenuator of one channel and the intermediate amplifier part of the other channel.
This is simply a matter of plugging coaxial cables.

Be careful if a reed relay in the attenuators must be replaced. Such a relay consists of a glass tube, containing the contact points, and a coil. The coil is fitted around the glass tube, with a piece of foil in between for shielding. Since the glass tube is rather fragile, the connection wire of the relay must be bent and soldered with caution. Do not twists the connection wires, as this may cause broken glass-metal seal and unreliable contact inside the glass-tube.

To locate an instability problem in the Y-amplifier, both input- or both output cables of the delay-line may be taken loose. The trace must then be approx. in the middle of the screen.
Check also the c.r.t. side-connection pins on corrosion.

3.5.3. Time-base and X-amplifier

- The easiest way to test the time-base generator (we refer here to the main time-base generator, but a similar procedure applies to the delayed time-base) is to remove transistor TS868, switch in a low sweep speed and short-circuit the collector of TS871 to earth. During the time that this short-circuit is open, the time-base capacitor (869) is charged. The charging process can be traced through the time-base unit, where the changing level must be measured in all circuits.
  A fault is then located at a point which does not follow the changing level.
  The final stage of the X-amplifier can be checked by interconnecting both emittors of TS1206 and TS1207; the displayed dot must then be approx. in the middle of the screen.

3.5.4. Instability

Instability of the display could be caused by bad contacts in the multipole- or the miniature coaxial connectors. If necessary check also the wire clamping in the multipole plugs (good contact of the multipole earth connections of the power supply output is very important).
The inner female contact of the miniature coaxial connectors could be cleaned with a dia 0,75 mm twist drill.

3.6. MAINTENANCE

After removal, the cabinet plates may be cleaned with a mild non-abrasive household detergent. Do not use chemical solutions such as trichlorethylene and acetone.

The text plate may be cleaned with the same detergent, with alcohol or with white spirit. Always use a soft cloth or cotton wool.

3.7 PARTS LISTS

Transistors

Type	*Ordering Code*	*Stamp. if SOT-23*	*Encapsulation*	*Quantity in one set*
BC547	5322 130 44257		TO-92	1
BC549	4822 130 40964		TO-92	51
BC549C	5322 130 44246		TO-92	7
BC557	5322 130 44256		TO-92	2
BC559	4822 130 40963		TO-92	17
BC559B	5322 130 44358		TO-92	1
BCY71	5322 130 40373		TO-18	2
BD135	5322 130 40645		TO-126	1
BD232 (*1)	4822 130 40913		TO-126	2
BD262	5322 130 44357		TO-126	1
BDY93/01 (*2)	5322 130 44457		TO-126	1
BF199	5322 130 44154		TO-92	8
BF324	5322 130 44396		TO-92	10
BF336	4822 130 40908		TO-39	2
BFS17	5322 130 40781	E1	SOT-23	7
BFS17R	5322 130 44338	E4	SOT-23	5
BFW44	5322 130 40672		TO-39	2
BFY90	5322 130 40493		TO-72	9
BRY39	5322 130 40482		TO-72	1
BSW68	5322 130 40714		TO-39	1
BSX20	5322 130 40417		TO-18	4
BSX21	5322 130 40321		TO-18	4
BSX60	5322 130 44019		TO-39	1
CNY43	5322 130 44395		—	1
FW5324	5322 130 40142		TO-18	2
FW5497	5322 130 40673		TO-18	2
2N2894	5322 130 40018		TO-18	3
2N2894A	5322 130 44127		TO-18	1
537-BSY	5322 130 44359	B3	SOT-23	1

*1) Both transistors TS1804 and 1806 must be selected to the same h_{fe} at $V_c = 5$ and $I_c = 200$ mA.
*2) Transistor TS1807 must be selected together with the value of resistor R1817. Refer to chapter 3.4.2.7.

Diodes

Type	*Ordering Code*		*Quantity in one set*
BA148	4822 130 30839		9
BA182	5322 130 30644		3
BAV45	5322 130 34037		1
BAW62	5322 130 30613		50
BAX12	5322 130 30424		14
BAX17	5322 130 30605		6
BYX10	5322 130 30195		1
BAX55/600	4822 130 30817		1
CQY24	4822 130 30885	LED	2
BY179	5322 130 30521	rect. stack	1
BY187	5322 130 34136	H.V. diode	1

Voltage reference diodes

Type	*Ordering Code*	*Quantity in one set*
BZX61/C13	5322 130 30771	1
BZX61/C27	5322 130 34381	1
BZX61/C75	5322 130 34034	1
BZX75/C1V4	5322 130 34047	2
BZX75/C2V8	5322 130 34048	2
BZX75/C3V6	5322 130 30765	1
BZX79/B7V5	4822 130 30861	2
BZX79/B8V2	5322 130 34382	2
BZX79/B47	5322 130 34383	1
BZX79/B62	5322 130 34384	2
BZX79/C4V7	4822 130 30773	1
BZX79/C5V6	5322 130 30759	3
BZX79/C9V1	5322 130 34069	2
BZX79/C10	5322 130 30774	2
BZX79/C22	5322 130 30783	1
BZX88/C3V3	5322 130 30392	1

Integrated circuits

Item	*Service Code*	*Description*	*Type or Code Stamp*	*Quantity in one set*
IC101	5322 209 84424	Impedance converter	4022 105 25160	2
IC301 ... 602	5322 209 84355	Transistor-diode array (SOT43)	OQ002	6
IC1301	5322 209 80068	Op. ampl.	TAA521/709C	1
IC1601	5322 209 84143	Quad. 2 inp. NAND	SN7400/FJH131	1
IC1602	5322 209 84414	Quad. 2 inp. NAND	SN7426/FJH301	1
IC1603	5322 209 84166	JK m/s flip-flop	SN7472/FJJ111	1
IC1801	5322 209 80245	Voltage regulator	TBA281/723C	1

Various electrical parts

Item	*Service Code*	*Description*
B1	5322 131 24029	Cathode raytube type D14-125GH/08
B1301	5322 131 90021	Stab. tube type ZA1004
L1301	5322 150 14015	Trace rotation coil for c.r.t. (approx. 430 ohms)
L1302, 1303	5322 526 14001	R.f. choke ring
L1401, 1800	5322 281 64154	R.f. choke 144 μH 0.3 ohm
L1803	5322 152 24027	Choke 20 mH (250 mA); 8.3 ohms
L1804, 1807	5322 158 10052	R.f. bead
L1806, 1808	5322 281 64154	R.f. choke 144 μH 0.3 ohms
L1809, 1812	5322 158 10052	R.f. bead
L1811, 1813	5322 281 64154	R.f. choke 144 μH 0.3 ohms
L1814, 1817	5322 158 10052	R.f. bead
L1816, 1818	5322 281 64154	R.f. choke 144 μH 0.3 ohms
L1819	5322 158 10052	R.f. bead
L1821	5322 281 64154	R.f. choke 144 μH 0.3 ohms
LA1, LA2	5322 134 44123	Lamp type 370 18 V 40 mA
RE101 ... 112	5322 281 64149	Relay coil (440 ohms)
	5322 280 24036	Glass tube relay contact

Item	*Service Code*	*Description*
SK1 ... 21	5322 276 14158	Switch segment
SK10	5322 273 44043	Rotary switch
T1401	5322 148 84023	EHT conv. transformer (1-5: L = 1 H R = 1225 ohms; 6-10: R = 1,4 ohms; 8-9: R = 0,1 ohms)
T1801	5322 146 14069	Base drive transformer
T1802	5322 148 84022	Converter transformer
VL1	4822 253 30024	Fuse 1.6 Amp slow-blow

3.7.1. Mechanical parts

Item	*Order number*	*Description*
Front (Fig. 3.15)		
1	5322 414 14011	Knob for push-button switches
	5322 276 14158	Switch segment
2	5322 414 34134	Knob, dia 10 mm
	5322 492 64337	Retaining spring
	5322 414 74015	Cover, grey with dash
3	5322 414 34079	Knob, dia 18.7 mm, shaft dia. 6 mm
	5322 414 34091	Knob, dia 10 mm, shaft dia. 4 mm
	5322 414 74029	Cover, blue with dash
4	5322 414 34133	Knob, dia 10 mm, shaft dia 1/8"
	5322 414 74031	Cover, grey
5	5322 414 34081	Knob, dia 24 mm, shaft dia. 6 mm
	5322 414 34119	Knob, dia 14 mm, shaft dia. 4 mm
	5322 414 74016	Cover, blue with dash
6	5322 447 94147	Upper cabinet plate, complete
7	5322 417 24024	Quick-fastener, complete
8	5322 498 54043	Grip bracket, right-hand side (r)
	5322 498 54044	Grip bracket, left-hand side (l)
	5322 528 34113	Ratchet block (of bracket)
	5322 535 74401	Locking pin
	5322 492 54155	Spring
	5322 498 54045	Grip bar
	5322 455 84051	Blue text strip in grip bar
	5322 498 54042	Plastic strip at rear of grip bar
9	5322 455 84041	Front text plate
10	5322 447 94146	Lower cabinet plate, complete
11	5322 462 44155	Rubber foot
12	5322 267 10004	BNC socket
13	5322 535 80523	Earth socket
	5322 505 14178	Serrated nut for earth socket
14	5322 255 44088	Holder for led
15	5322 267 14014	Cal. socket
	5322 405 94073	Cal. current loop
	5322 505 14184	Plastic nut
	5322 263 54003	BNC-cal. socket adapter
16	5322 447 94145	Aluminium side strip of cabinet
	4822 502 30047	Self tapping screw for side strip
17	5322 480 34046	Contrast filter, grey
	5322 480 34047	Contrast filter, green
18	5322 451 34004	Bezel

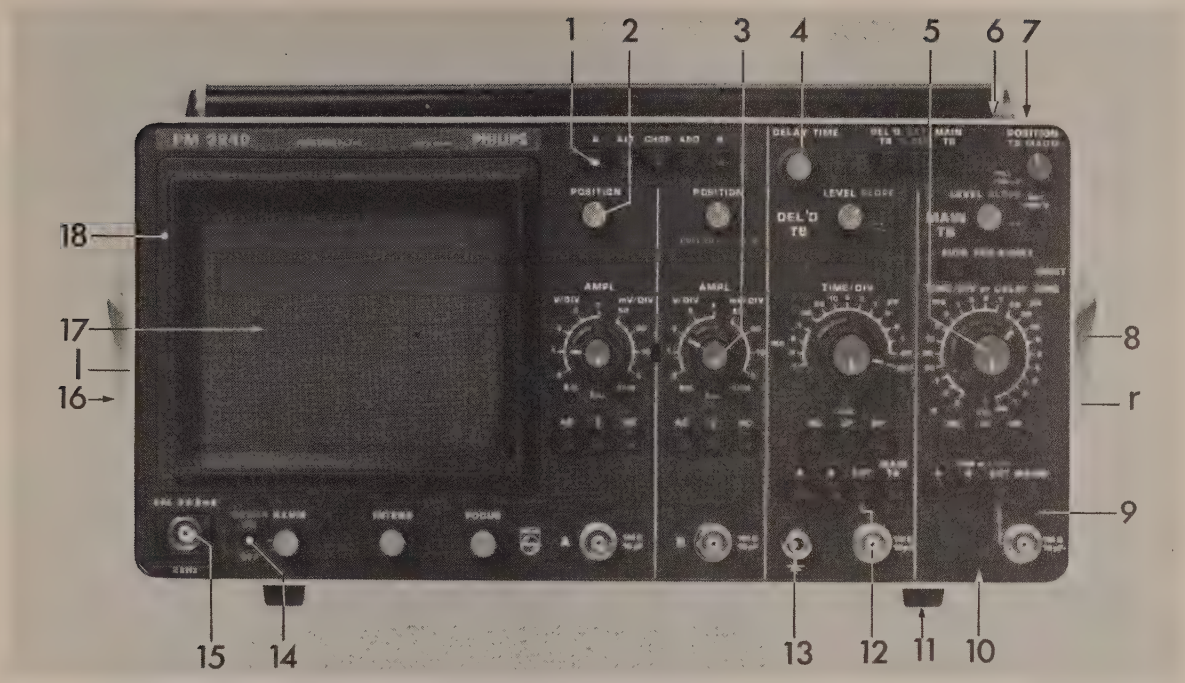


Fig. 3.15. Mechanical parts, front view

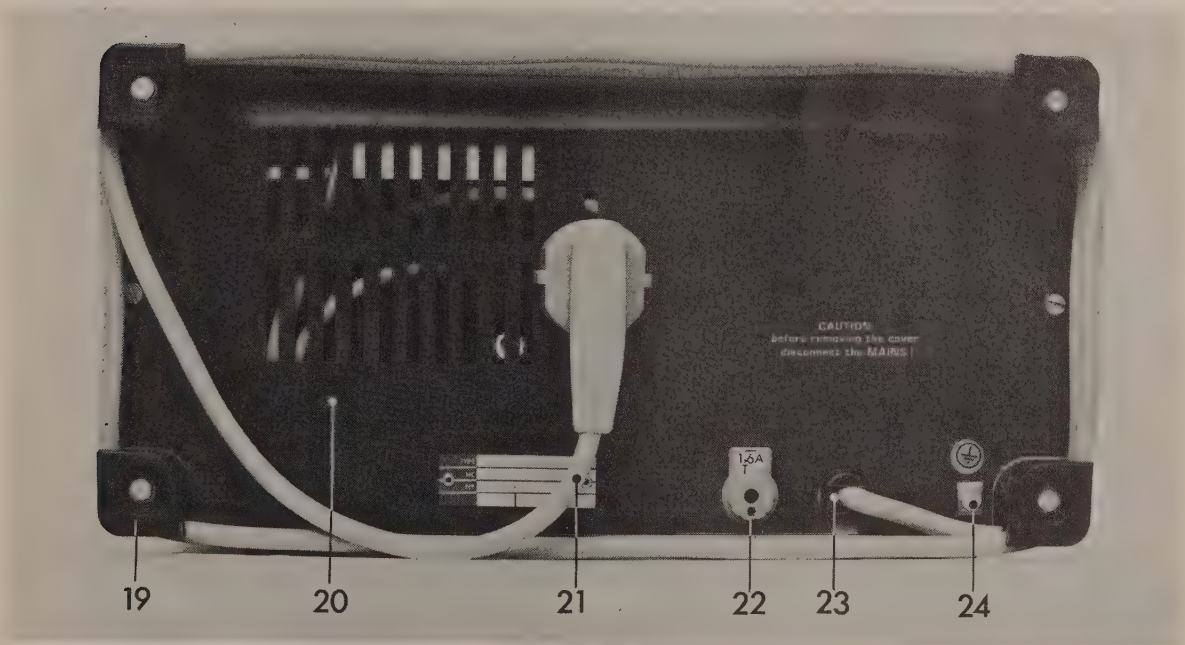


Fig. 3.16. Mechanical parts, rear view

Item	*Order number*	*Description*
Rear (Fig. 3.16)		
19	5322 462 44154	Foot, complete
20	5322 447 94148	Rear cabinet plate
21	5322 321 14001	Mains cable with plug
22	5322 256 34019	Fuse holder
23	5322 325 60119	Cable cleat
24	5322 405 94046	Earth terminal

Top view (Fig. 3.17)

25	5322 447 94143	Cast-aluminium front plate
26	5322 381 14151	Clamping buffer for c.r.t. front
27	5322 255 24015	Socket for lamps
	5322 134 44123	Lamp type 370 18 V-40 mA
28	5322 532 84037	Mu-metal c.r.t. shield
	5322 150 14015	Trace rotation coil for c.r.t.
29	4822 505 10029	Square nut M3 in side strip
30	5322 532 74014	Rubber sleeve of c.r.t.
	5322 255 70159	C.r.t. socket
31	5322 447 94144	Cast-aluminium rear plate

Bottom view (Fig. 3.18)

32	5322 414 34161	Knob of pre-set pot. meters
33	5322 320 14027	Coax. socket, mounted on p.c. board
34	5322 535 94656	Plastic spindle

Miscellaneous

Coaxial cables

5322 320 14031	440 mm cable with plugs (between Z-ampl. unit and intern: ampl. unit)
5322 320 14027	500 mm cable with plugs

Multi pole plugs and sockets

4822 266 30071	3-pole plug (at cable)	(Stocko MKF 803-1-0-303)
4822 265 30121	3-pole socket (on p.c. board)	(Stocko MKS 823-1-0-303)
4822 266 30072	4-pole plug	(Stocko MKF 804-1-0-404)
4822 265 30119	4-pole socket	(Stocko MKS 824-1-0-404)
4822 266 30073	6-pole plug	(Stocko MKF 806-1-0-606)
4822 265 30117	6-pole socket	(Stocko MKS 826-1-0-606)
4822 266 40057	7-pole plug	(Stocko MKF 807-1-0-707)
4822 265 40119	7-pole socket	(Stocko MKS 827-1-0-707)

Switch mounting parts (ref. Fig. 3.6)

5322 405 94074	Male clamping piece
5322 405 94075	Female clamping piece
5322 502 11142	Screw M3 x 20

Front cover box

5322 447 94169	Front cover box, complete
5322 535 94761	Locking key
5322 466 85467	Inner plate
5322 492 34453	Spring
4822 530 70126	Circlip

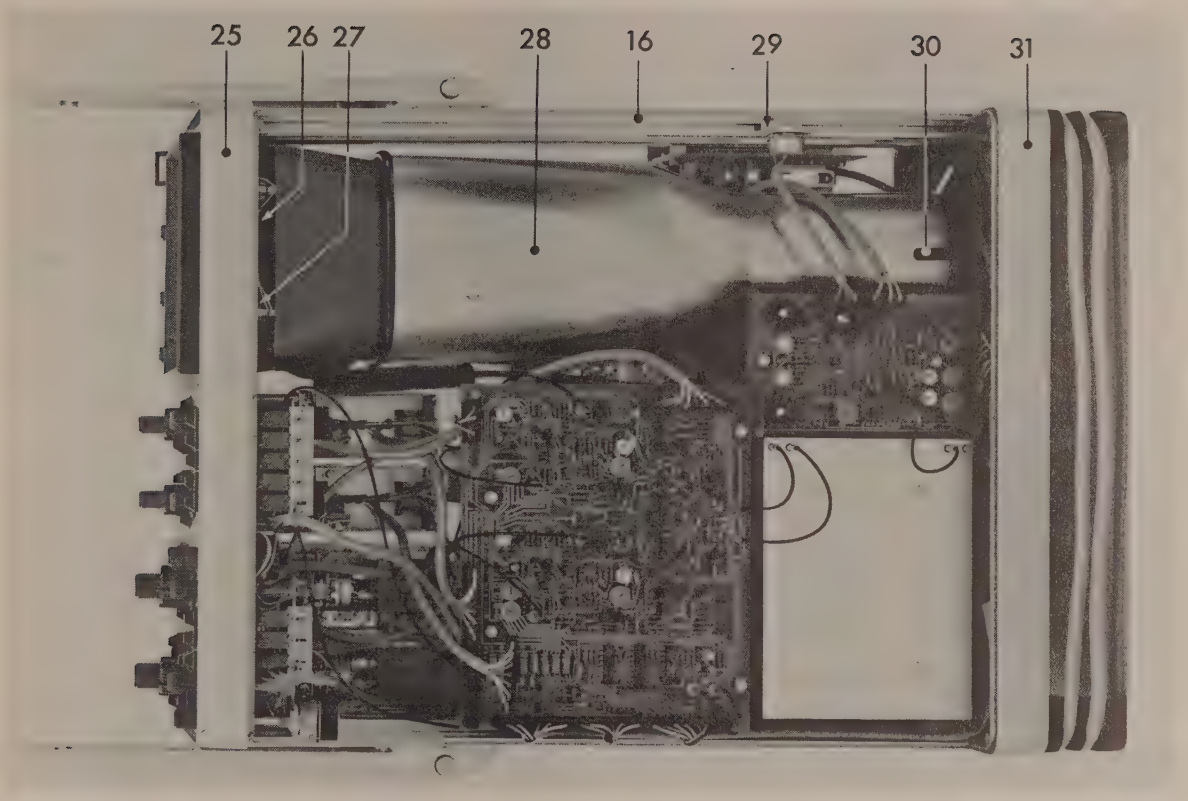


Fig. 3.17. Mechanical parts, top view

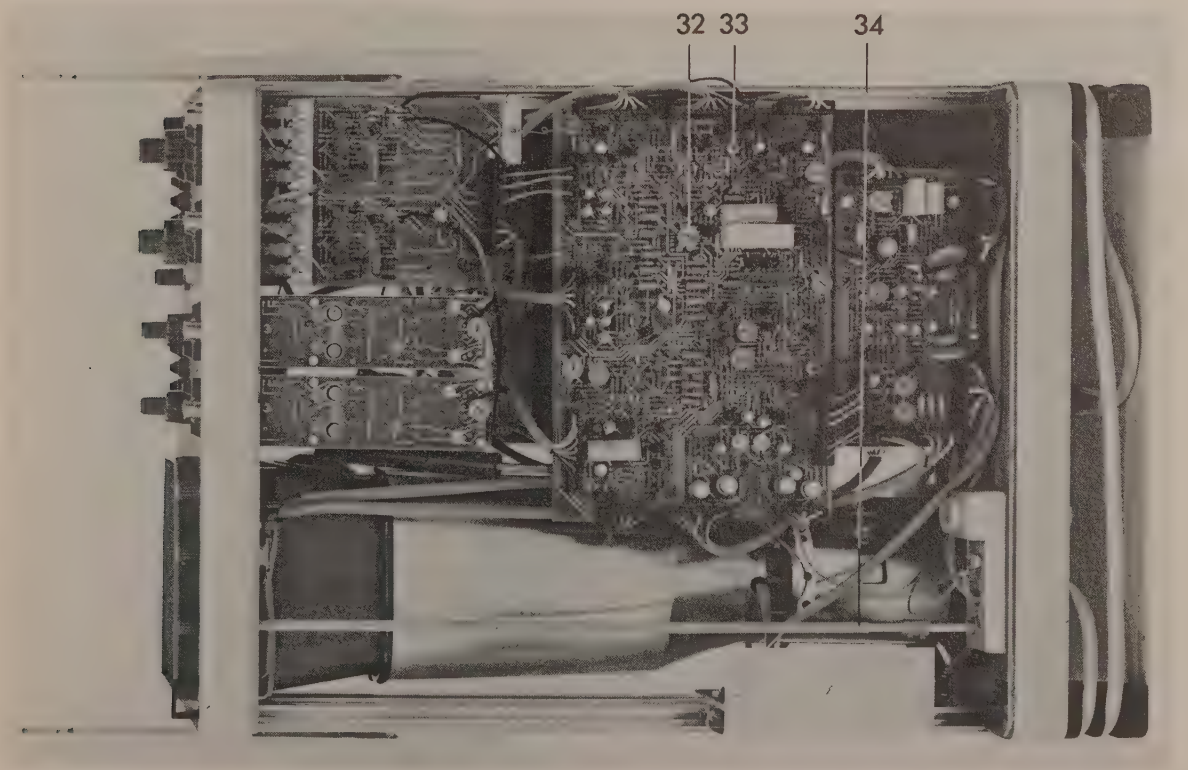


Fig. 3.18. Mechanical parts, bottom view

Item	*Order number*	*Description*
Special parts and tools		
(3)	5322 505 14185	Special nut for attenuator switch
(5)	5322 505 14186	Special nut for potentiometer unit
	5322 395 54023	Tool for item (3). Ref. fig. 3.7
	5322 395 54024	Tool for item (5). Ref. fig. 3.8

Units	
Y-attenuator compl.	5322 105 34027
Intermediate amplifier	5322 216 54121
Delay-line	5322 320 44015
Final Y-amplifier	5322 216 54122
Trigger source unit	5322 216 54123
Time-base and X-amplifier	5322 216 54118
MTB switch compl.	5322 105 34025
DTB switch compl.	5322 105 34026
Z-amplifier	5322 216 54119
1600 V generator	5322 216 54117
8 kV multiplier	5322 218 64048
Power supply	5322 216 54116

All these units are complete and pre-adjusted.

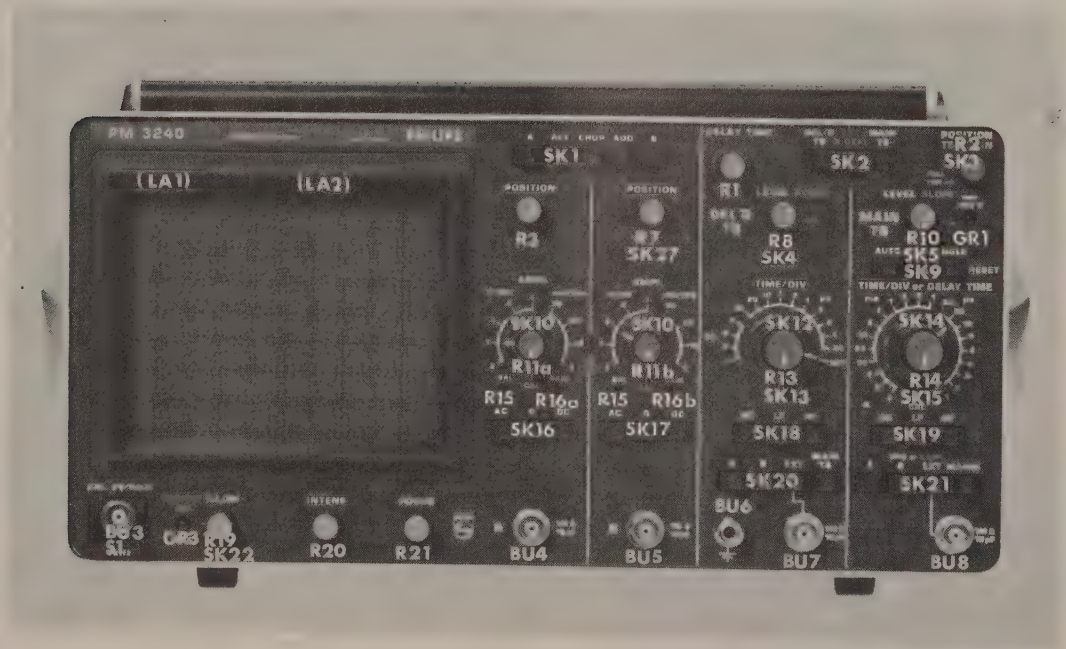


Fig. 3.19. Electrical item numbers, front panel

3.7.2. ELECTRICAL PARTS

Capacitors

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C 101	5322 125 64009	3P		500	TRIMMER
C 102	5322 125 64015	4,5P		500	TRIMMER
C 103	5322 123 34001	30P	10	500	MICA
C 104	4822 121 40171	22N	10	400	POLYESTER FOIL
C 105	4822 122 31041	3,3P		100	CERAMIC PLATE
C 106	4822 122 31203	39P	2	500	CERAMIC PLATE
C 107	5322 125 64012	1,5P		500	TRIMMER
C 108	5322 125 64014	3P		500	TRIMMER
C 109	5322 125 64009	3P		500	TRIMMER
C 111	5322 125 64015	4,5P		500	TRIMMER
C 112	5322 123 10168	300P	10	500	MICA
C 113	4822 122 30103	22 N-20	+100	40	CERAMIC PLATE
C 114	4822 122 30103	22 N-20	+100	40	CERAMIC PLATE
C 115	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 117	4822 122 30043	3,9 P	0,25%	100	CERAMIC PLATE
C 118	4822 122 31081	100 P	2%	100	CERAMIC PLATE
C 119	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 121	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 301	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 302	4822 125 50045	22P		100	TRIMMER
C 303	4822 122 31054	10P	2	100	CERAMIC PLATE
C 304	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 306	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 307	4822 122 31054	10P	2	100	CERAMIC PLATE
C 308	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 309	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 311	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 312	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 313	4822 122 31054	10P	2	100	CERAMIC PLATE
C 314	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 315	4822 122 30128	4,7N			CERAMIC PLATE
C 316	4822 125 50045	22P		100	TRIMMER
C 317	4822 122 30045	27P	2	100	CERAMIC PLATE
C 318	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 319	4822 122 30045	27P	2	100	CERAMIC PLATE
C 320	4822 122 31058	15P	2	100	CERAMIC PLATE
C 321	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 324	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 325	4822 122 30034	470P	2	100	CERAMIC PLATE
C 326	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 327	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 328	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 329	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 401	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 402	4822 125 50045	22P		100	TRIMMER
C 403	4822 122 31054	10P	2	100	CERAMIC PLATE
C 404	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 406	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 407	4822 122 31054	10P	2	100	CERAMIC PLATE
C 408	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 409	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 410	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 411	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 412	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 413	4822 122 31054	10P	2	100	CERAMIC PLATE
C 414	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 415	4822 122 30128	4,7 N	10	100	CERAMIC PLATE
C 416	4822 125 50045	22P		100	TRIMMER
C 417	4822 122 30045	27P	2	100	CERAMIC PLATE
C 418	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 419	4822 122 30045	27P	2	100	CERAMIC PLATE
C 420	4822 122 31058	15P	2	100	CERAMIC PLATE
C 421	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 422	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 423	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 424	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 425	4822 122 30034	470P	2	100	CERAMIC PLATE
C 426	4822 122 30043	10N	-20+100	40	CERAMIC PLATE

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C 427	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 428	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 429	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 431	4822 122 30043	10 N-20	+100	40	CERAMIC PLATE
C 432	4822 122 30043	10 N-20	+100	40	CERAMIC PLATE
C 501	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 502	4822 122 31054	10P	2	100	CERAMIC PLATE
C 503	4822 122 30043	10 N- 2	0+100	40	CERAMIC PLATE
C 504	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 505	4822 122 31054	10P	2	100	CERAMIC PLATE
C 506	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 507	4822 122 31054	10P	2	100	CERAMIC PLATE
C 511	4822 124 20467	15MU		16	ELECTROLYTIC
C 513	4822 124 20467	15MU		16	ELECTROLYTIC
C 514	4822 124 20467	15MU		16	ELECTROLYTIC
C 516	4822 124 20467	15MU		16	ELECTROLYTIC
C 517	4822 124 20467	15MU		16	ELECTROLYTIC
C 518	4822 124 20467	15MU		16	ELECTROLYTIC
C 519	4822 124 20467	15MU		16	ELECTROLYTIC
C 521	4822 124 20467	15MU		16	ELECTROLYTIC
C 601	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 602	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 603	4822 125 50045	22P		100	TRIMMER
C 604	4822 122 31074	56P	2	100	CERAMIC PLATE
C 605	4822 122 31054	10P	2	100	CERAMIC PLATE
C 606	4822 125 50045	22		100	TRIMMER
C 607	4822 122 30103	22N	-20+100	40	CERAMIC PLATE
C 608	4822 122 30027	1N	10	100	CERAMIC PLATE
C 609	4822 122 31167	2,2N	10	100	CERAMIC PLATE
C 614	4822 122 31054	10P	2	100	CERAMIC PLATE
C 616	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 618	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 619	4822 122 31054	10P	2	100	CERAMIC PLATE
C 621	4822 122 31054	10P	2	100	CERAMIC PLATE
C 622	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 623	4822 121 41161	100N	10	250	POLYESTER FOIL
C 624	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 626	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 627	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 628	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 629	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 631	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 632	4822 121 41161	100N	10	250	POLYESTER FOIL
C 633	4822 122 31054	10P	2	100	CERAMIC PLATE
C 634	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 651	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 652	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 653	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 701	4822 122 31198	18P	2	500	CERAMIC PLATE
C 702	4822 121 40146	100N	10	400	POLYESTER FOIL
C 703	4822 122 31202	100 P	2	500	CERAMIC PLATE
C 704	4822 122 30103	22N	-20+100	40	CERAMIC PLATE
C 706	4822 122 31038	2,7P	0,25P	100	CERAMIC PLATE
C 707	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 708	4822 122 31177	470P	10	100	CERAMIC PLATE
C 709	4822 122 31177	470P	10	100	CERAMIC PLATE
C 751	4822 122 31198	18P	2	500	CERAMIC PLATE
C 752	4822 121 40146	100N	10	400	POLYESTER FOIL
C 753	4822 122 31202	100 P	2	500	CERAMIC PLATE
C 756	4822 122 31038	2,7P	0,25	100	CERAMIC PLATE
C 757	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 758	4822 122 31177	470P	10	100	CERAMIC PLATE
C 759	4822 122 31177	470P	10	100	CERAMIC PLATE
C 761	4822 122 30103	22N	-20+100	40	CERAMIC PLATE
C 762	4822 122 30103	22N	-20+100	40	CERAMIC PLATE
C 801	4822 124 20467	15MU		16	ELECTROLYTIC
C 802	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 803	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 804	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 805	4822 122 31036	2,2 P 0	,25	100	CERAMIC PLATE

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C 806	4822 124 20467	15MU		16	ELECTROLYTIC
C 807	4822 124 20467	15MU		16	ELECTROLYTIC
C 808	4822 122 30043	10 N=20	+100	40	CERAMIC PLATE
C 809	4822 122 30043	10 N=20	+100	40	CERAMIC PLATE
C 851	4822 124 20467	15MU		16	ELECTROLYTIC
C 852	4822 124 20467	15MU		16	ELECTROLYTIC
C 853	4822 124 20467	15MU		16	ELECTROLYTIC
C 854	4822 124 20467	15MU		16	ELECTROLYTIC
C 855	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 856	4822 122 31061	18P	2	100	CERAMIC PLATE
C 857	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 858	4822 124 20483	6,8MU		40	ELECTROLYTIC
C 859	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 860	4822 122 31047	5,6P	0,25	100	CERAMIC PLATE
C 861	4822 122 31061	18P	2	100	CERAMIC PLATE
C 862	4822 122 30114	2,2N	10	100	CERAMIC PLATE
C 863	4822 124 20584	2,2MU		63	ELECTROLYTIC
C 864	4822 124 20467	15MU		16	ELECTROLYTIC
C 866	5322 121 54076	453P	1	250	POLYSTYRENE FOIL
C 867	5322 121 40224	4,7MU	10	100	POLYESTER FOIL
C 868	4822 124 20467	15MU		16	ELECTROLYTIC
C 869	5322 121 54108	47N	1	63	POLYSTYRENE FOIL
C 871	4822 122 30103	22N	=20+100	40	CERAMIC PLATE
C 872	4822 122 30034	470P	2	100	CERAMIC PLATE
C 873	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 874	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 876	4822 122 30103	22N	=20+100	40	CERAMIC PLATE
C 877	4822 124 20467	15MU		16	ELECTROLYTIC
C 878	4822 124 20467	15MU		16	ELECTROLYTIC
C 879	4822 122 30043	10 N=20	+100	40	CERAMIC PLATE
C 1001	4822 124 20467	15MU		16	ELECTROLYTIC
C 1002	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1003	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1004	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1005	4822 122 31036	2,2 P 0	,25	100	CERAMIC PLATE
C 1006	4822 124 20467	15MU		16	ELECTROLYTIC
C 1007	4822 124 20467	15MU		16	ELECTROLYTIC
C 1008	4822 122 30043	10 N=20	+100	40	CERAMIC PLATE
C 1009	4822 122 30043	10 N=20	+100	40	CERAMIC PLATE
C 1051	4822 124 20467	15MU		16	ELECTROLYTIC
C 1052	4822 124 20467	15MU		16	ELECTROLYTIC
C 1053	4822 124 20467	15MU		16	ELECTROLYTIC
C 1054	4822 124 20467	15MU		16	ELECTROLYTIC
C 1056	4822 122 31061	18P	2	100	CERAMIC PLATE
C 1057	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1058	4822 122 31061	18P	2	100	CERAMIC PLATE
C 1059	5322 121 54076	453P	1	250	POLYSTYRENE FOIL
C 1060	4822 122 31047	5,6P	0,25	100	CERAMIC PLATE
C 1061	5322 121 54108	47N	1	63	POLYSTYRENE FOIL
C 1062	4822 122 30034	470P	2	100	CERAMIC PLATE
C 1063	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1064	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1066	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1067	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1068	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1069	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1201	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1202	4822 122 31215	0,68P	0,25	100	CERAMIC PLATE
C 1203	4822 125 50077	5,5P		100	TRIMMER
C 1204	4822 122 31116	2,2N	10	500	CERAMIC PLATE
C 1205	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1206	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1207	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1208	4822 125 50077	5,5P		100	TRIMMER
C 1209	4822 122 31215	0,68P	0,25	100	CERAMIC PLATE
C 1211	4822 122 31116	2,2N	10	500	CERAMIC PLATE
C 1212	4822 122 30043	10N	=20+100	40	CERAMIC PLATE
C 1213	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1214	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1216	4822 122 30043	10N	=20+100	40	CERAMIC PLATE

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C 1301	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 1302	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 1303	4822 122 30104	1P	0,25	100	CERAMIC PLATE
C 1304	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 1306	4822 122 30054	1,2N	10	100	CERAMIC PLATE
C 1307	4822 122 30098	3,9N	10	40	CERAMIC PLATE
C 1308	5322 122 54004	470P	20	4K	CERAMIC DISK
C 1309	5322 122 54004	470P	20	4K	CERAMIC DISK
C 1310	4822 121 41138	15N	10	250	POLYESTER FOIL
C 1311	4822 122 31081	100P	2	100	CERAMIC PLATE
C 1312	5322 122 54006	3,3N	-20+50	3KV	CERAMIC DISK
C 1313	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1314	5322 122 54006	3,3N	-20+50	3KV	CERAMIC DISK
C 1316	4822 124 20468	33MU		16	ELECTROLYTIC
C 1317	5322 121 40233	680N	10	100	POLYESTER FOIL
C 1318	4822 121 50611	20N	1	63	POLYSTYRENE FOIL
C 1319	4822 124 20468	33MU		16	ELECTROLYTIC
C 1401	4822 124 20497	15MU		63	ELECTROLYTIC
C 1402	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1403	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1404	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1406	5322 122 54006	3,3N	-20+50	3KV	CERAMIC DISK
C 1407	4822 121 40363	10N	10	1600	POLYESTER FOIL
C 1416	5322 122 54004	470P	20	4K	CERAMIC DISK
C 1417	5322 122 54004	470P	20	4K	CERAMIC DISK
C 1418	5322 122 54004	470P	20	4K	CERAMIC DISK
C 1419	5322 122 54004	470P	20	4K	CERAMIC DISK
C 1421	5322 122 54004	470P	20	4K	CERAMIC DISK
C 1601	4822 122 30027	1N	2	100	CERAMIC PLATE
C 1602	4822 122 30094	220P	2	100	CERAMIC PLATE
C 1603	4822 122 30135	820P	2	100	CERAMIC PLATE
C 1604	4822 121 41161	100 N	10	250	POLYESTER FOIL
C 1606	4822 122 30043	10N	-20+100	40	CERAMIC PLATE
C 1607	4822 122 30043	10 N-20	+100	40	CERAMIC PLATE
C 1608	4822 122 30043	10 N-20	+100	40	CERAMIC PLATE
C 1801	5322 121 44142	220N	10	250	POLYESTER FOIL
C 1802	5322 122 44009	2,2N	10	250	CERAMIC DISK
C 1803	5322 122 44009	2,2N	10	250	CERAMIC DISK
C 1804	5322 121 44142	220N	10	250	POLYESTER FOIL
C 1806	4822 124 40066	50+50MU		400	ELECTROLYTIC
C 1807	4822 124 20324	4MU		400	ELECTROLYTIC
C 1808	4822 124 20324	4MU		400	ELECTROLYTIC
C 1809	4822 124 20306	50MU		100	ELECTROLYTIC
C 1810	4822 124 20581	220MU		4	ELECTROLYTIC
C 1812	4822 124 20583	1MU		63	ELECTROLYTIC
C 1814	4822 124 20467	15MU		16	ELECTROLYTIC
C 1816	4822 124 20461	47MU		10	ELECTROLYTIC
C 1817	4822 121 40443	680N	10	100	POLYESTER FOIL
C 1818	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1819	4822 122 30094	220P	10	100	CERAMIC PLATE
C 1821	4822 124 20459	22MU		10	ELECTROLYTIC
C 1822	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1823	4822 124 20587	100MU		25	ELECTROLYTIC
C 1824	4822 121 41169	220N	10	250	POLYESTER FOIL
C 1826	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1827	4822 124 20457	470MU		6,3	ELECTROLYTIC
C 1828	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1829	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1830	4822 121 40298	4,7 N	10	1600	POLYESTER FOIL
C 1831	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1832	4822 121 41161	100N	10	250	POLYESTER FOIL
C 1833	4822 124 20497	15MU		63	ELECTROLYTIC
C 1834	4822 124 20497	15MU		63	ELECTROLYTIC
C 1836	4822 124 20469	68MU		16	ELECTROLYTIC
C 1837	4822 124 20469	68MU		16	ELECTROLYTIC
C 1838	4822 124 20469	68MU		16	ELECTROLYTIC
C 1839	4822 124 20469	68MU		16	ELECTROLYTIC
C 1841	4822 124 20454	150MU		6,3	ELECTROLYTIC
C 1842	4822 124 20454	150MU		6,3	ELECTROLYTIC
C 1843	4822 124 20454	150MU		6,3	ELECTROLYTIC

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C 1844	4822 124 20454	150MU		6,3	ELECTROLYTIC
C 1846	4822 124 20454	150MU		6,3	ELECTROLYTIC
C 1847	4822 124 20454	150MU		6,3	ELECTROLYTIC
C 1848	4822 124 20454	150MU		6,3	ELECTROLYTIC
C 1849	4822 124 20454	150MU		6,3	ELECTROLYTIC

Resistors

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 1	5322 103 64016	5K	5	2W	W.W. POTENTIOMETER
R 2	5322 101 44015	50K	20	CP16	POTM LIN + SWITCH
R 3	5322 101 24077	470E	20	0,1W	POTM LIN
R 7	5322 101 94005	500	20	CP16	POTENTIOMETER
R 8	5322 101 44014	100K	20	CP16	POTM LIN + SWITCH
R 10	5322 101 44014	100K	20	CP16	POTM LIN + SWITCH
R 11	5322 101 54006	10K	20	0,1W	POTM LOG + SWITCH
R 13	5322 101 40041	4,7K	20	0,25W	POTM LIN + SWITCH
R 14	5322 101 40041	4,7K	20	0,25W	POTM LIN + SWITCH
R 15	5322 101 24046	100E	20	0,1W	POTM LIN
R 16	5322 101 34016	47K	20	0,1W	POTM LOG
R 19	5322 101 24055	25K	20	CP16	POTM LIN
R 20	5322 101 24059	10K	20	CP16	POTM LIN
R 21	5322 101 24062	2,2M	20	0,1W	POTM LIN
R 101	4822 111 30067	33E	5	CR16	CARBON
R 102	5322 116 55021	920K	0,25	MR30	METAL FILM
R 103	5322 111 30383	68E	5	CR25	CARBON
R 104	5322 116 55067	88,9K	0,25	MR25	METAL FILM
R 106	4822 111 30245	47E	5	CR25	CARBON
R 107	5322 116 54892	200K	0,25	MR25	METAL FILM
R 108	5322 116 55023	800K	0,25	MR30	METAL FILM
R 109	4822 111 30309	560E	5	CR25	CARBON
R 111	4822 111 30309	560E	5	CR25	CARBON
R 112	4822 111 30069	39E	5	CR16	CARBON
R 113	5322 116 55022	992K	0,25	MR30	METAL FILM
R 114	5322 116 55066	8,08K	0,25	MR25	METAL FILM
R 116	5322 111 30383	68E	5	CR25	CARBON
R 118	5322 116 50592	442E	1	MR25	METAL FILM
R 119	5322 116 50592	442E	1	MR25	METAL FILM
R 121	4822 111 30347	10E	5	CR16	CARBON
R 123	5322 116 54499	249E	1	MR25	METAL FILM
R 124	4822 110 63036	2,7E	5	CR25	CARBON
R 126	4822 110 63043	3,9E	5	CR25	CARBON
R 128	4822 100 10035	10K	20	0,05W	CARBON TRIMMING POTM
R 129	5322 116 50672	51,1K	1	MR25	METAL FILM
R 301	5322 116 50524	3,01K	1	MR25	METAL FILM
R 302	5322 116 54508	301E	1	MR25	METAL FILM
R 303	4822 111 30067	33E	5	CR16	CARBON
R 304	5322 116 50524	3,01K	1	MR25	METAL FILM
R 305	5322 116 54464	86,6E	1	MR25	METAL FILM
R 306	4822 111 30347	10E	5	CR16	CARBON
R 307	5322 116 50492	46,4E	1	MR25	METAL FILM
R 308	5322 116 50568	4,99E	1	MR25	METAL FILM
R 309	5322 116 50492	46,4E	1	MR25	METAL FILM
R 310	5322 116 34022	47E	5	0,5W	NTC
R 311	4822 111 30347	10E	5	CR16	CARBON
R 312	4822 111 30067	33E	5	CR16	CARBON
R 313	5322 116 50515	1,78K	1	MR25	METAL FILM
R 314	5322 116 54597	5,36K	1	MR25	METAL FILM
R 316	5322 116 50452	10E	1	MR25	METAL FILM
R 317	5322 116 50571	715E	1	MR25	METAL FILM
R 318	4822 111 30245	47E	5	CR25	CARBON
R 319	4822 111 30347	10E	5	CR16	CARBON
R 320	5322 116 54464	86,6E	1	MR25	METAL FILM
R 321	4822 111 30067	33E	5	CR16	CARBON
R 322	5322 116 54492	178E	1	MR25	METAL FILM
R 323	4822 111 30067	33E	5	CR16	CARBON
R 324	5322 116 54576	2,37K	1	MR25	METAL FILM
R 326	5322 116 54587	3,65K	1	MR25	METAL FILM
R 327	4822 111 30067	33E	5	CR16	CARBON

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 328	4822 111 30067	33E	5	CR16	CARBON
R 329	5322 116 54492	178E	1	MR25	METAL FILM
R 331	4822 111 30347	10E	5	CR16	CARBON
R 332	5322 116 50571	715E	1	MR25	METAL FILM
R 333	4822 111 30245	47E	5	CR25	CARBON
R 334	5322 116 50452	10E	1	MR25	METAL FILM
R 336	4822 111 30067	33E	5	CR16	CARBON
R 337	5322 116 54613	8,66K	1	MR25	METAL FILM
R 338	5322 116 54005	3,32K	1	MR25	METAL FILM
R 339	4822 111 30067	33E	5	CR16	CARBON
R 340	5322 116 54606	7,15K	1	MR25	METAL FILM
R 341	5322 116 50926	40,2E	1	MR25	METAL FILM
R 342	5322 101 14057	1K	20	0,05W	CARBON TRIMMING POTM
R 343	5322 116 54515	348E	1	MR25	METAL FILM
R 344	5322 116 50926	40,2E	1	MR25	METAL FILM
R 346	4822 111 30067	33E	5	CR16	CARBON
R 347	4822 111 30324	100E	5	CR16	CARBON
R 348	5322 116 54469	100E	1	MR25	METAL FILM
R 349	5322 116 50926	40,2E	1	MR25	METAL FILM
R 351	4822 100 10079	47K	20	0,05W	CARBON TRIMMING POTM
R 352	5322 116 54519	402E	1	MR25	METAL FILM
R 353	5322 116 54012	6,81K	1	MR25	METAL FILM
R 354	4822 111 30067	33E	5	CR16	CARBON
R 355	5322 116 50452	10E	1	MR25	METAL FILM
R 356	5322 116 50926	40,2E	1	MR25	METAL FILM
R 357	5322 116 50481	22,6K	1	MR25	METAL FILM
R 358	4822 111 30324	100E	5	CR16	CARBON
R 359	5322 116 50515	1,78K	1	MR25	METAL FILM
R 360	5322 116 50483	38,3K	1	MR25	METAL FILM
R 361	5322 116 50581	2,49K	1	MR25	METAL FILM
R 367	4822 111 30067	33E	5	CR16	CARBON
R 368	4822 111 30067	33E	5	CR16	CARBON
R 374	4822 111 30067	33E	5	CR16	CARBON
R 376	4822 111 30067	33E	5	CR16	CARBON
R 377	4822 111 30067	33E	5	CR16	CARBON
R 378	5322 116 54469	100E	1	MR25	METAL FILM
R 379	5322 116 50621	536E	1	MR25	METAL FILM
R 381	4822 111 30067	33E	5	CR16	CARBON
R 382	5322 116 54469	100E	1	MR25	METAL FILM
R 383	4822 111 30067	33E	5	CR16	CARBON
R 384	5322 116 54613	8,66K	1	MR25	METAL FILM
R 386	5322 116 50524	3,01K	1	MR25	METAL FILM
R 387	5322 116 50527	33,2E	1	MR25	METAL FILM
R 388	5322 116 54469	100E	1	MR25	METAL FILM
R 401	5322 116 50524	3,01K	1	MR25	METAL FILM
R 402	5322 116 54508	301E	1	MR25	METAL FILM
R 403	4822 111 30067	33E	5	CR16	CARBON
R 404	5322 116 50524	3,01K	1	MR25	METAL FILM
R 405	5322 116 54464	86,6E	1	MR25	METAL FILM
R 406	4822 111 30347	10E	5	CR16	CARBON
R 407	5322 116 50492	46,4E	1	MR25	METAL FILM
R 408	5322 116 50568	4,99E	1	MR25	METAL FILM
R 409	5322 116 50492	46,4E	1	MR25	METAL FILM
R 410	5322 116 34022	47E	5	0,5W	NTC
R 411	4822 111 30347	10E	5	CR16	CARBON
R 412	4822 111 30067	33E	5	CR16	CARBON
R 413	5322 116 50515	1,78K	1	MR25	METAL FILM
R 414	5322 116 54597	5,36K	1	MR25	METAL FILM
R 416	5322 116 50452	10E	1	MR25	METAL FILM
R 417	5322 116 50571	715E	1	MR25	METAL FILM
R 418	4822 111 30245	47E	5	CR25	CARBON
R 419	4822 111 30347	10E	5	CR16	CARBON
R 420	5322 116 54464	86,6E	1	MR25	METAL FILM
R 421	4822 111 30067	33E	5	CR16	CARBON
R 422	5322 116 54492	178E	1	MR25	METAL FILM
R 423	4822 111 30067	33E	5	CR16	CARBON
R 424	5322 116 54576	2,37K	1	MR25	METAL FILM
R 426	5322 116 54587	3,65K	1	MR25	METAL FILM
R 427	4822 111 30067	33E	5	CR16	CARBON
R 428	4822 111 30067	33E	5	CR16	CARBON
R 429	5322 116 54492	178E	1	MR25	METAL FILM
R 430	5322 116 50442	48,7K	1	MR25	METAL FILM
R 431	4822 111 30347	10E	5	CR16	CARBON
R 432	5322 116 50571	715E	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 433	4822 111 30245	47E	5	CR25	CARBON
R 434	5322 116 50452	10E	1	MR25	METAL FILM
R 435	4822 100 10035	10K	20	0,05W	CARBON TRIMMING POTM
R 436	4822 111 30067	33E	5	CR16	CARBON
R 437	5322 116 54613	8,66K	1	MR25	METAL FILM
R 438	5322 116 54005	3,32K	1	MR25	METAL FILM
R 439	4822 111 30067	33E	5	CR16	CARBON
R 440	5322 116 54606	7,15K	1	MR25	METAL FILM
R 441	5322 116 50926	40,2E	1	MR25	METAL FILM
R 442	5322 101 14057	1K	20	0,05W	CARBON TRIMMING POTM
R 443	5322 116 54515	348E	1	MR25	METAL FILM
R 444	5322 116 50926	40,2E	1	MR25	METAL FILM
R 446	4822 111 30067	33E	5	CR16	CARBON
R 447	4822 111 30324	100E	5	CR16	CARBON
R 448	5322 116 54469	100E	1	MR25	METAL FILM
R 449	5322 116 50926	40,2E	1	MR25	METAL FILM
R 451	4822 100 10079	47K	20	0,05W	CARBON TRIMMING POTM
R 452	5322 116 54519	402E	1	MR25	METAL FILM
R 453	5322 116 54012	6,81K	1	MR25	METAL FILM
R 454	4822 111 30067	33E	5	CR16	CARBON
R 455	5322 116 50452	10E	1	MR25	METAL FILM
R 456	5322 116 50926	40,2E	1	MR25	METAL FILM
R 457	5322 116 50481	22,6K	1	MR25	METAL FILM
R 458	4822 111 30324	100E	5	CR16	CARBON
R 460	5322 116 50483	38,3K	1	MR25	METAL FILM
R 461	5322 116 50581	2,49K	1	MR25	METAL FILM
R 462	5322 116 54585	3,48K	1	MR25	METAL FILM
R 463	5322 116 54585	3,48K	1	MR25	METAL FILM
R 464	5322 116 50581	2,49K	1	MR25	METAL FILM
R 465	5322 116 54585	3,48K	1	MR25	METAL FILM
R 466	5322 116 54585	3,48K	1	MR25	METAL FILM
R 467	4822 111 30067	33E	5	CR16	CARBON
R 468	4822 111 30067	33E	5	CR16	CARBON
R 469	5322 111 30074	56E	5	CR25	CARBON
R 471	4822 111 30067	33E	5	CR16	CARBON
R 472	4822 111 30067	33E	5	CR16	CARBON
R 473	5322 111 30074	56E	5	CR25	CARBON
R 474	4822 111 30067	33E	5	CR16	CARBON
R 476	4822 111 30067	33E	5	CR16	CARBON
R 477	4822 111 30067	33E	5	CR16	CARBON
R 478	5322 116 54469	100E	1	MR25	METAL FILM
R 479	5322 116 50621	536E	1	MR25	METAL FILM
R 481	4822 111 30067	33E	5	CR16	CARBON
R 482	5322 116 54469	100E	1	MR25	METAL FILM
R 483	4822 111 30067	33E	5	CR16	CARBON
R 484	5322 116 54613	8,66K	1	MR25	METAL FILM
R 486	5322 116 50524	3,01K	1	MR25	METAL FILM
R 487	5322 116 50527	33,2E	1	MR25	METAL FILM
R 488	5322 116 54469	100E	1	MR25	METAL FILM
R 501	5322 116 54525	511E	1	MR25	METAL FILM
R 502	5322 116 54549	1K	1	MR25	METAL FILM
R 504	5322 116 50452	10E	1	MR25	METAL FILM
R 506	5322 116 54494	187E	1	MR25	METAL FILM
R 507	5322 116 54525	511E	1	MR25	METAL FILM
R 508	5322 116 54549	1K	1	MR25	METAL FILM
R 511	4822 111 30245	47E	5	CR25	CARBON
R 512	5322 116 50561	590E	1	MR25	METAL FILM
R 513	4822 111 30067	33E	5	CR16	CARBON
R 514	5322 116 54492	178E	1	MR25	METAL FILM
R 515	5322 116 50568	4,99E	1	MR25	METAL FILM
R 516	5322 116 54444	53,6E	1	MR25	METAL FILM
R 517	5322 116 54492	178E	1	MR25	METAL FILM
R 518	4822 111 30067	33E	5	CR16	CARBON
R 519	5322 116 54444	53,6E	1	MR25	METAL FILM
R 521	4822 111 30067	33E	5	CR16	CARBON
R 522	5322 116 54534	681E	1	MR25	METAL FILM
R 523	5322 116 50569	95,3E	1	MR25	METAL FILM
R 524	5322 116 50561	590E	1	MR25	METAL FILM
R 526	4822 111 30245	47E	5	CR25	CARBON
R 531	5322 116 50568	4,99E	1	MR25	METAL FILM
R 532	5322 116 50568	4,99E	1	MR25	METAL FILM
R 533	5322 116 54258	9,53E	1	MR25	METAL FILM
R 534	5322 116 50568	4,99E	1	MR25	METAL FILM
R 536	5322 116 54258	9,53E	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 537	5322 116 50568	4,99E	1	MR25	METAL FILM
R 538	5322 116 54258	9,53E	1	MR25	METAL FILM
R 539	5322 116 54258	9,53E	1	MR25	METAL FILM
R 541	5322 116 50568	4,99E	1	MR25	METAL FILM
R 542	5322 116 50568	4,99E	1	MR25	METAL FILM
R 601	5322 116 50926	40,2E	1	MR25	METAL FILM
R 602	5322 116 54506	287E	1	MR25	METAL FILM
R 603	4822 111 30067	33E	5	CR16	CARBON
R 604	5322 116 54492	178E	1	MR25	METAL FILM
R 606	5322 116 50676	196E	1	MR25	METAL FILM
R 607	5322 116 54519	402E	1	MR25	METAL FILM
R 608	4822 111 30067	33E	5	CR16	CARBON
R 609	5322 116 54492	178E	1	MR25	METAL FILM
R 610	5322 116 50524	3,01K	1	MR25	METAL FILM
R 611	5322 116 50926	40,2E	1	MR25	METAL FILM
R 612	5322 116 54506	287E	1	MR25	METAL FILM
R 613	5322 116 50506	154E	1	MR25	METAL FILM
R 614	4822 111 30067	33E	5	CR16	CARBON
R 615	5322 116 50524	3,01K	1	MR25	METAL FILM
R 616	5322 116 54444	53,6E	1	MR25	METAL FILM
R 617	4822 111 30067	33E	5	CR16	CARBON
R 618	5322 116 54444	53,6E	1	MR25	METAL FILM
R 619	4822 100 10075	100E	20	0,05W	CARBON TRIMMING POTM
R 621	4822 100 10036	4,7K	20	0,05W	CARBON TRIMMING POTM
R 622	4822 100 10035	10K	20	0,05W	CARBON TRIMMING POTM
R 623	5322 116 54655	30,1K	1	MR25	METAL FILM
R 624	5322 116 54643	20,5K	1	MR25	METAL FILM
R 627	4822 111 30245	47E	5	CR25	CARBON
R 628	4822 111 30067	33E	5	CR16	CARBON
R 629	5322 116 54608	7,5K	1	MR25	METAL FILM
R 630	4822 111 30067	33E	5	CR16	CARBON
R 631	5322 116 50556	4,42K	1	MR25	METAL FILM
R 632	4822 111 30245	47E	5	CR25	CARBON
R 633	4822 111 30067	33E	5	CR16	CARBON
R 634	4822 111 30067	33E	5	CR16	CARBON
R 636	4822 111 30067	33E	5	CR16	CARBON
R 637	5322 116 50457	215E	1	MR25	METAL FILM
R 638	5322 116 50669	205E	1	MR25	METAL FILM
R 639	5322 116 54451	61,9E	1	MR25	METAL FILM
R 641	4822 100 10038	470E	20	0,05W	CARBON TRIMMING POTM
R 642	5322 116 50457	215E	1	MR25	METAL FILM
R 644	5322 116 50669	205E	1	MR25	METAL FILM
R 646	5322 116 54451	61,9E	1	MR25	METAL FILM
R 647	4822 111 30067	33E	5	CR16	CARBON
R 648	4822 111 30245	47E	5	CR25	CARBON
R 649	5322 116 50515	1,78K	1	MR25	METAL FILM
R 650	5322 116 54615	9,09K	1	MR25	METAL FILM
R 651	5322 116 54585	3,48K	1	MR25	METAL FILM
R 652	5322 116 50474	42,2K	1	MR25	METAL FILM
R 653	5322 116 50417	162E	1	MR25	METAL FILM
R 654	5322 116 54011	5,62K	1	MR25	METAL FILM
R 655	5322 116 50904	30,1E	1	MR25	METAL FILM
R 656	5322 116 54557	1,21K	1	MR25	METAL FILM
R 657	5322 116 50579	3,16K	1	MR25	METAL FILM
R 658	5322 116 54516	365E	1	MR25	METAL FILM
R 659	4822 111 30067	33E	5	CR16	CARBON
R 660	5322 116 54516	365E	1	MR25	METAL FILM
R 661	5322 116 50509	4,87K	1	MR25	METAL FILM
R 662	5322 116 50579	3,16K	1	MR25	METAL FILM
R 663	5322 116 54012	6,81K	1	MR25	METAL FILM
R 664	5322 116 54557	1,21K	1	MR25	METAL FILM
R 665	5322 116 54615	9,09K	1	MR25	METAL FILM
R 666	5322 116 54011	5,62K	1	MR25	METAL FILM
R 667	4822 111 30245	47E	5	CR25	CARBON
R 668	5322 116 50515	1,78K	1	MR25	METAL FILM
R 669	5322 116 54585	3,48K	1	MR25	METAL FILM
R 671	5322 116 50474	42,2K	1	MR25	METAL FILM
R 672	5322 116 50417	162E	1	MR25	METAL FILM
R 681	5322 116 50568	4,99E	1	MR25	METAL FILM
R 682	5322 116 50568	4,99E	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 683	5322 116 50568	4,99E	1	MR25	METAL FILM
R 684	5322 101 20408	100K	20	0,1W	CARBON POTM LIN
R 701	5322 116 50527	33,2E	1	MR25	METAL FILM
R 702	5322 116 54263	681K	1	MR30	METAL FILM
R 703	5322 116 54549	1K	1	MR25	METAL FILM
R 704	5322 116 54549	1K	1	MR25	METAL FILM
R 706	5322 116 54743	301K	1	MR25	METAL FILM
R 707	5322 116 50527	33,2E	1	MR25	METAL FILM
R 708	5322 116 50527	33,2E	1	MR25	METAL FILM
R 709	5322 116 50527	33,2E	1	MR25	METAL FILM
R 710	5322 116 54038	221K	1	MR25	METAL FILM
R 711	5322 116 50491	22,6E	1	MR25	METAL FILM
R 712	5322 116 54619	10K	1	MR25	METAL FILM
R 713	5322 116 54624	11,5K	1	MR25	METAL FILM
R 714	5322 116 50527	33,2E	1	MR25	METAL FILM
R 716	5322 116 50664	2,05K	1	MR25	METAL FILM
R 717	5322 116 54549	1K	1	MR25	METAL FILM
R 718	5322 116 54545	909E	1	MR25	METAL FILM
R 719	5322 116 50527	33,2E	1	MR25	METAL FILM
R 721	5322 116 50555	1,27K	1	MR25	METAL FILM
R 722	5322 116 54525	511E	1	MR25	METAL FILM
R 723	5322 116 50527	33,2E	1	MR25	METAL FILM
R 724	5322 116 50527	33,2E	1	MR25	METAL FILM
R 726	5322 116 54549	1K	1	MR25	METAL FILM
R 727	5322 116 50527	33,2E	1	MR25	METAL FILM
R 728	5322 116 54469	100E	1	MR25	METAL FILM
R 729	5322 116 50731	10,5K	1	MR25	METAL FILM
R 731	5322 116 50527	33,2E	1	MR25	METAL FILM
R 732	5322 116 50527	33,2E	1	MR25	METAL FILM
R 733	5322 116 50527	33,2E	1	MR25	METAL FILM
R 734	5322 116 50731	10,5K	1	MR25	METAL FILM
R 751	5322 116 50527	33,2E	1	MR25	METAL FILM
R 752	5322 116 54263	681K	1	MR30	METAL FILM
R 753	5322 116 54549	1K	1	MR25	METAL FILM
R 754	5322 116 54549	1K	1	MR25	METAL FILM
R 756	5322 116 54743	301K	1	MR25	METAL FILM
R 757	5322 116 50527	33,2E	1	MR25	METAL FILM
R 758	5322 116 50527	33,2E	1	MR25	METAL FILM
R 759	5322 116 50527	33,2E	1	MR25	METAL FILM
R 760	5322 116 54038	221K	1	MR25	METAL FILM
R 761	5322 116 50491	22,6E	1	MR25	METAL FILM
R 762	5322 116 54619	10K	1	MR25	METAL FILM
R 763	5322 116 54624	11,5K	1	MR25	METAL FILM
R 764	5322 116 50527	33,2E	1	MR25	METAL FILM
R 766	5322 116 50664	2,05K	1	MR25	METAL FILM
R 768	5322 116 54545	909E	1	MR25	METAL FILM
R 769	5322 116 50527	33,2E	1	MR25	METAL FILM
R 771	5322 116 50555	1,27K	1	MR25	METAL FILM
R 772	5322 116 54525	511E	1	MR25	METAL FILM
R 773	5322 116 50527	33,2E	1	MR25	METAL FILM
R 774	5322 116 50527	33,2E	1	MR25	METAL FILM
R 776	5322 116 54549	1K	1	MR25	METAL FILM
R 777	4822 110 63189	1,2M	10	CR25	CARBON
R 778	5322 116 54696	100K	1	MR25	METAL FILM
R 779	5322 116 50731	10,5K	1	MR25	METAL FILM
R 781	5322 116 50527	33,2E	1	MR25	METAL FILM
R 784	5322 116 50731	10,5K	1	MR25	METAL FILM
R 801	5322 111 30396	22E	5	CR16	CARBON
R 802	5322 111 30396	22E	5	CR16	CARBON
R 803	5322 116 54012	6,81K	1	MR25	METAL FILM
R 804	4822 111 30263	3,3K	5	CR16	CARBON
R 806	5322 116 50586	1,54K	1	MR25	METAL FILM
R 807	5322 116 50895	18,7E	1	MR25	METAL FILM
R 808	5322 116 50895	18,7E	1	MR25	METAL FILM
R 809	5322 111 30396	22E	5	CR16	CARBON
R 811	5322 116 54012	6,81K	1	MR25	METAL FILM
R 812	5322 116 54536	750E	1	MR25	METAL FILM
R 813	5322 111 30396	22E	5	CR16	CARBON
R 814	5322 116 54592	4,02K	1	MR25	METAL FILM
R 816	5322 111 30396	22E	5	CR16	CARBON

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 817	5322 116 50415	1,15K	1	MR25	METAL FILM
R 818	5322 116 50415	1,15K	1	MR25	METAL FILM
R 819	5322 111 30396	22E	5	CR16	CARBON
R 821	4822 110 63054	10E	5	CR25	CARBON
R 822	5322 116 54683	68,1K	1	MR25	METAL FILM
R 823	5322 116 50636	2,74K	1	MR25	METAL FILM
R 824	5322 116 54683	68,1K	1	MR25	METAL FILM
R 826	5322 116 54552	1,05K	1	MR25	METAL FILM
R 827	5322 116 50635	1,47K	1	MR25	METAL FILM
R 828	5322 116 50635	1,47K	1	MR25	METAL FILM
R 829	5322 116 54552	1,05K	1	MR25	METAL FILM
R 831	5322 111 30396	22E	5	CR16	CARBON
R 832	5322 111 30396	22E	5	CR16	CARBON
R 833	5322 116 50527	33,2E	1	MR25	METAL FILM
R 834	5322 116 50506	154E	1	MR25	METAL FILM
R 836	5322 116 54508	301E	1	MR25	METAL FILM
R 837	5322 116 54552	1,05K	1	MR25	METAL FILM
R 838	5322 111 30396	22E	5	CR16	CARBON
R 839	5322 116 54552	1,05K	1	MR25	METAL FILM
R 840	5322 111 30396	22E	5	CR16	CARBON
R 841	5322 116 54576	2,37K	1	MR25	METAL FILM
R 842	5322 116 54519	402E	1	MR25	METAL FILM
R 843	4822 110 63054	10E	5	CR25	CARBON
R 844	4822 110 63054	10E	5	CR25	CARBON
R 851	4822 110 63036	2,2E	5	CR25	CARBON
R 852	4822 110 63036	2,2E	5	CR25	CARBON
R 853	4822 110 63036	2,2E	5	CR25	CARBON
R 854	4822 110 63036	2,2E	5	CR25	CARBON
R 856	5322 116 54564	1,5K	1	MR25	METAL FILM
R 857	5322 111 44156	510E	5	CR25	CARBON
R 858	5322 116 54549	1K	1	MR25	METAL FILM
R 859	5322 116 54619	10K	1	MR25	METAL FILM
R 861	5322 116 54629	14K	1	MR25	METAL FILM
R 862	5322 111 34094	620E	5	CR25	CARBON
R 863	4822 111 30303	8,2K	5	CR25	CARBON
R 864	4822 111 30267	1,5K	5	CR16	CARBON
R 866	4822 111 30119	3K	5	CR16	CARBON
R 867	5322 116 50561	590E	1	MR25	METAL FILM
R 868	5322 116 54011	5,62K	1	MR25	METAL FILM
R 869	5322 116 54585	3,48K	1	MR25	METAL FILM
R 871	5322 111 44153	15E	5	CR16	CARBON
R 872	5322 116 54474	110E	1	MR25	METAL FILM
R 873	5322 101 14084	22K	20	0,05W	CARBON TRIMMING POTM
R 874	5322 116 54661	34,8K	1	MR25	METAL FILM
R 876	5322 116 54619	10K	1	MR25	METAL FILM
R 877	5322 116 54597	5,36K	1	MR25	METAL FILM
R 878	5322 116 50415	1,15K	1	MR25	METAL FILM
R 879	5322 116 54481	130E	1	MR25	METAL FILM
R 880	5322 116 54585	3,48K	1	MR25	METAL FILM
R 881	5322 116 50676	196E	1	MR25	METAL FILM
R 882	5322 116 54696	100K	1	MR25	METAL FILM
R 883	5322 116 54632	14,7K	1	MR25	METAL FILM
R 884	5322 116 54632	14,7K	1	MR25	METAL FILM
R 885	5322 116 50583	5,9K	1	MR25	METAL FILM
R 886	5322 116 50481	22,6K	1	MR25	METAL FILM
R 887	5322 116 50459	422E	1	MR25	METAL FILM
R 888	5322 116 54005	3,32K	1	MR25	METAL FILM
R 889	5322 116 54603	6,49K	1	MR25	METAL FILM
R 890	5322 111 30396	22E	5	CR16	CARBON
R 891	5322 116 50675	2,26K	1	MR25	METAL FILM
R 892	5322 116 54608	7,5K	1	MR25	METAL FILM
R 893	4822 111 30067	33E	5	CR16	CARBON
R 894	5322 116 50509	4,87K	1	MR25	METAL FILM
R 895	5322 116 50586	1,54K	1	MR25	METAL FILM
R 897	5322 116 54519	402E	1	MR25	METAL FILM
R 898	5322 116 54534	681E	1	MR25	METAL FILM
R 899	5322 116 50636	2,74K	1	MR25	METAL FILM
R 901	5322 116 54549	1K	1	MR25	METAL FILM
R 902	4822 111 30067	33E	5	CR16	CARBON
R 903	5322 116 50527	33,2E	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 904	5322 116 50636	2,74K	1	MR25	METAL FILM
R 905	5322 116 54587	3,65K	1	MR25	METAL FILM
R 906	5322 111 30396	22E	5	CR16	CARBON
R 907	5322 116 50556	4,42K	1	MR25	METAL FILM
R 908	4822 111 30067	33E	5	CR16	CARBON
R 909	5322 116 50798	898E	0,5	MR24C	METAL FILM
R 911	5322 116 50579	3,16K	1	MR25	METAL FILM
R 912	5322 116 54595	5,11K	1	MR25	METAL FILM
R 913	5322 116 50664	2,05K	1	MR25	METAL FILM
R 914	4822 100 10036	4,7K	20	0,05W	CARBON TRIMMING POTM
R 916	5322 116 50481	22,6K	1	MR25	METAL FILM
R 917	5322 116 54549	1K	1	MR25	METAL FILM
R 918	5322 116 54549	1K	1	MR25	METAL FILM
R 919	5322 116 50559	27,4K	1	MR25	METAL FILM
R 921	5322 116 50559	27,4K	1	MR25	METAL FILM
R 922	5322 116 50556	4,42K	1	MR25	METAL FILM
R 923	5322 116 50556	4,42K	1	MR25	METAL FILM
R 924	5322 116 50481	22,6K	1	MR25	METAL FILM
R 926	5322 116 54011	5,62K	1	MR25	METAL FILM
R 927	5322 116 54011	5,62K	1	MR25	METAL FILM
R 928	5322 111 30396	22E	5	CR16	CARBON
R 929	5322 116 54627	13,3K	1	MR25	METAL FILM
R 931	4822 111 30352	82E	5	CR25	CARBON
R 932	4822 111 30245	47E	5	CR25	CARBON
R 933	5322 111 30396	22E	5	CR16	CARBON
R 934	5322 111 30279	33K	5	CR16	CARBON
R 936	5322 116 54565	1,62K	1	MR25	METAL FILM
R 937	5322 111 44156	510E	5	CR25	CARBON
R 938	5322 116 54603	6,49K	1	MR25	METAL FILM
R 939	5322 111 44156	510E	5	CR25	CARBON
R 941	4822 111 30327	220E	5	CR16	CARBON
R 942	5322 116 54632	14,7K	1	MR25	METAL FILM
R 943	5322 116 54516	365E	1	MR25	METAL FILM
R 944	5322 116 50664	2,05K	1	MR25	METAL FILM
R 946	5322 116 54608	7,5K	1	MR25	METAL FILM
R 947	5322 116 50508	487E	1	MR25	METAL FILM
R 948	5322 116 54617	9,53K	1	MR25	METAL FILM
R 949	5322 116 54576	2,37K	1	MR25	METAL FILM
R 961	5322 116 54408	909K	1	MR30	METAL FILM
R 962	5322 116 54762	365K	1	MR30	METAL FILM
R 963	5322 116 54939	35,2K	0,5	MR24C	METAL FILM
R 964	5322 116 54276	17,2K	0,5	MR24C	METAL FILM
R 966	5322 116 50888	8,16K	0,5	MR24C	METAL FILM
R 967	5322 116 54832	2,71K	0,5	MR24C	METAL FILM
R 968	5322 116 50798	898E	0,5	MR24C	METAL FILM
R 969	5322 116 54722	182K	1	MR25	METAL FILM
R 971	5322 116 54977	89,8K	0,5	MR24C	METAL FILM
R 1001	5322 111 30396	22E	5	CR16	CARBON
R 1002	5322 111 30396	22E	5	CR16	CARBON
R 1003	5322 116 54012	6,81K	1	MR25	METAL FILM
R 1004	4822 111 30263	3,3K	5	CR16	CARBON
R 1006	5322 116 50586	1,54K	1	MR25	METAL FILM
R 1007	5322 116 50895	18,7E	1	MR25	METAL FILM
R 1008	5322 116 50895	18,7E	1	MR25	METAL FILM
R 1009	5322 111 30396	22E	5	CR16	CARBON
R 1011	5322 116 54012	6,81K	1	MR25	METAL FILM
R 1012	5322 116 54536	750E	1	MR25	METAL FILM
R 1013	5322 111 30396	22E	5	CR16	CARBON
R 1014	5322 116 54592	4,02K	1	MR25	METAL FILM
R 1016	5322 111 30396	22E	5	CR16	CARBON
R 1017	5322 116 50415	1,15K	1	MR25	METAL FILM
R 1018	5322 116 50415	1,15K	1	MR25	METAL FILM
R 1019	5322 111 30396	22E	5	CR16	CARBON
R 1021	4822 110 63054	10E	5	CR25	CARBON
R 1022	5322 116 54683	68,1K	1	MR25	METAL FILM
R 1023	5322 116 50636	2,74K	1	MR25	METAL FILM
R 1024	5322 116 54683	68,1K	1	MR25	METAL FILM
R 1026	5322 116 54552	1,05K	1	MR25	METAL FILM
R 1027	5322 116 50635	1,47K	1	MR25	METAL FILM
R 1028	5322 116 50635	1,47K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 1029	5322 116 54552	1,05K	1	MR25	METAL FILM
R 1031	5322 111 30396	22E	5	CR16	CARBON
R 1032	5322 111 30396	22E	5	CR16	CARBON
R 1033	5322 116 50527	33,2E	1	MR25	METAL FILM
R 1034	5322 116 50506	154E	1	MR25	METAL FILM
R 1036	5322 116 54508	301E	1	MR25	METAL FILM
R 1037	5322 116 54552	1,05K	1	MR25	METAL FILM
R 1038	5322 111 30396	22E	5	CR16	CARBON
R 1039	5322 116 54552	1,05K	1	MR25	METAL FILM
R 1040	5322 111 30396	22E	5	CR16	CARBON
R 1041	5322 116 54576	2,37K	1	MR25	METAL FILM
R 1042	5322 116 54519	402E	1	MR25	METAL FILM
R 1043	4822 110 63054	10E	5	CR25	CARBON
R 1044	4822 110 63054	10E	5	CR25	CARBON
R 1051	4822 110 63036	2,2E	5	CR25	CARBON
R 1052	4822 110 63036	2,2E	5	CR25	CARBON
R 1053	4822 110 63063	22E	5	CR25	CARBON
R 1054	4822 110 63036	2,2E	5	CR25	CARBON
R 1056	5322 116 54576	2,37K	1	MR25	METAL FILM
R 1057	5322 116 54525	511E	1	MR25	METAL FILM
R 1058	5322 116 54474	110E	1	MR25	METAL FILM
R 1059	5322 111 44153	15E	5	CR16	CARBON
R 1061	5322 116 54532	649E	1	MR25	METAL FILM
R 1062	5322 116 50729	4,22K	1	MR25	METAL FILM
R 1063	5322 116 54011	5,62K	1	MR25	METAL FILM
R 1064	5322 101 14084	22K	20	0,05W	CARBON TRIMMING POTM
R 1066	5322 116 54629	14K	1	MR25	METAL FILM
R 1067	5322 116 54597	5,36K	1	MR25	METAL FILM
R 1068	5322 116 54597	5,36K	1	MR25	METAL FILM
R 1069	5322 116 50415	1,15K	1	MR25	METAL FILM
R 1070	5322 116 54516	365E	1	MR25	METAL FILM
R 1071	5322 116 54648	24,9K	1	MR25	METAL FILM
R 1072	5322 116 54519	402E	1	MR25	METAL FILM
R 1073	5322 116 54545	909E	1	MR25	METAL FILM
R 1075	5322 111 30396	22E	5	CR16	CARBON
R 1076	5322 116 54597	5,36K	1	MR25	METAL FILM
R 1077	5322 116 54005	3,32K	1	MR25	METAL FILM
R 1078	5322 116 54603	6,49K	1	MR25	METAL FILM
R 1079	5322 116 50767	2,15K	1	MR25	METAL FILM
R 1081	4822 111 30067	33E	5	CR16	CARBON
R 1082	5322 116 54608	7,5K	1	MR25	METAL FILM
R 1083	5322 116 54635	16,9K	1	MR25	METAL FILM
R 1084	4822 111 30067	33E	5	CR16	CARBON
R 1086	5322 116 50798	898E	0,5	MR24C	METAL FILM
R 1087	4822 111 30067	33E	5	CR16	CARBON
R 1088	5322 116 50579	3,16K	1	MR25	METAL FILM
R 1089	5322 111 30396	22E	5	CR16	CARBON
R 1091	4822 111 30067	33E	5	CR16	CARBON
R 1092	5322 116 54587	3,65K	1	MR25	METAL FILM
R 1093	5322 116 54606	7,15K	1	MR25	METAL FILM
R 1094	5322 116 54595	5,11K	1	MR25	METAL FILM
R 1096	5322 116 50479	15,4K	1	MR25	METAL FILM
R 1097	5322 101 14084	22K	20	0,05W	CARBON TRIMMING POTM
R 1098	5322 116 54549	1K	1	MR25	METAL FILM
R 1099	5322 111 30278	27K	5	CR16	CARBON
R 1101	4822 111 30352	82E	5	CR25	CARBON
R 1102	4822 111 30245	47E	5	CR25	CARBON
R 1103	5322 111 30396	22E	5	CR16	CARBON
R 1104	5322 111 30396	22E	5	CR16	CARBON
R 1106	5322 111 30279	33K	5	CR16	CARBON
R 1107	5322 116 54565	1,62K	1	MR25	METAL FILM
R 1108	5322 116 54576	2,37K	1	MR25	METAL FILM
R 1109	5322 116 50514	64,9K	1	MR25	METAL FILM
R 1111	5322 116 54595	5,11K	1	MR25	METAL FILM
R 1112	5322 116 50586	1,54K	1	MR25	METAL FILM
R 1113	5322 116 54576	2,37K	1	MR25	METAL FILM
R 1114	5322 116 54557	1,21K	1	MR25	METAL FILM
R 1115	4822 100 10035	10K	20	0,05W	CARBON TRIMMING POTM
R 1116	5322 116 54469	100E	1	MR25	METAL FILM
R 1117	5322 116 54554	1,1K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 1118	5322 116 54576	2,37K	1	MR25	METAL FILM
R 1119	5322 116 54617	9,53K	1	MR25	METAL FILM
R 1121	5322 116 54561	1,33K	1	MR25	METAL FILM
R 1122	5322 116 50524	3,01K	1	MR25	METAL FILM
R 1123	5322 116 54561	1,33K	1	MR25	METAL FILM
R 1124	4822 111 30067	33E	5	CR16	CARBON
R 1126	4822 111 30067	33E	5	CR16	CARBON
R 1127	5322 116 54617	9,53K	1	MR25	METAL FILM
R 1128	5322 116 50583	5,9K	1	MR25	METAL FILM
R 1129	5322 116 54592	4,02K	1	MR25	METAL FILM
R 1131	5322 116 50451	21,5K	1	MR25	METAL FILM
R 1132	5322 116 54664	39,2K	1	MR25	METAL FILM
R 1163	5322 116 54939	35,2K	0,5	MR24C	METAL FILM
R 1164	5322 116 54276	17,2K	0,5	MR24C	METAL FILM
R 1166	5322 116 50888	8,16K	0,5	MR24C	METAL FILM
R 1167	5322 116 54832	2,71K	0,5	MR24C	METAL FILM
R 1168	5322 116 50798	898E	0,5	MR24C	METAL FILM
R 1169	5322 116 54722	182K	1	MR25	METAL FILM
R 1171	5322 116 54977	89,8K	0,5	MR24C	METAL FILM
R 1201	5322 116 54558	8,25K	1	MR25	METAL FILM
R 1202	5322 116 50479	15,4K	1	MR25	METAL FILM
R 1203	5322 116 50484	4,64K	1	MR25	METAL FILM
R 1204	4822 111 30067	33E	5	CR16	CARBON
R 1206	5322 116 54619	10K	1	MR25	METAL FILM
R 1207	5322 116 50671	2,61K	1	MR25	METAL FILM
R 1208	5322 116 54619	10K	1	MR25	METAL FILM
R 1209	4822 100 10029	2,2K	20	0,05W	CARBON TRIMMING POTM
R 1211	5322 116 50621	536E	1	MR25	METAL FILM
R 1212	5322 116 50515	1,78K	1	MR25	METAL FILM
R 1213	5322 116 50621	536E	1	MR25	METAL FILM
R 1214	5322 116 50511	48,7E	1	MR25	METAL FILM
R 1216	5322 116 50457	215E	1	MR25	METAL FILM
R 1217	4822 111 30333	1M	10	CR16	CARBON
R 1218	4822 111 30333	1M	10	CR16	CARBON
R 1219	5322 116 54619	10K	1	MR25	METAL FILM
R 1221	5322 116 50511	48,7E	1	MR25	METAL FILM
R 1222	5322 116 50579	3,16K	1	MR25	METAL FILM
R 1223	4822 110 10035	10K	20	0,05W	CARBON
R 1224	5322 116 50579	3,16K	1	MR25	METAL FILM
R 1225	5322 116 50728	1,87K	1	MR25	METAL FILM
R 1226	5322 116 54619	10K	1	MR25	METAL FILM
R 1227	5322 116 54545	909E	1	MR25	METAL FILM
R 1228	5322 116 54545	909E	1	MR25	METAL FILM
R 1229	4822 111 30067	33E	5	CR16	CARBON
R 1231	5322 116 50583	5,9K	1	MR25	METAL FILM
R 1232	5322 116 54012	6,81K	1	MR25	METAL FILM
R 1233	5322 116 50555	1,27K	1	MR25	METAL FILM
R 1234	5322 116 54716	162K	1	MR25	METAL FILM
R 1236	4822 111 30067	33E	5	CR16	CARBON
R 1237	5322 116 54661	34,8K	1	MR25	METAL FILM
R 1238	4822 111 30067	33E	5	CR16	CARBON
R 1239	5322 116 54549	1K	1	MR25	METAL FILM
R 1241	5322 116 54263	681K	1	MR30	METAL FILM
R 1242	5322 116 54661	34,8K	1	MR25	METAL FILM
R 1243	4822 111 30067	33E	5	CR16	CARBON
R 1244	5322 116 54623	11K	1	MR25	METAL FILM
R 1246	5322 116 54592	4,02K	1	MR25	METAL FILM
R 1247	5322 116 54589	3,83K	1	MR25	METAL FILM
R 1248	4822 111 30067	33E	5	CR16	CARBON
R 1249	5322 116 54661	34,8K	1	MR25	METAL FILM
R 1251	5322 116 54661	34,8K	1	MR25	METAL FILM
R 1252	5322 116 54549	1K	1	MR25	METAL FILM
R 1253	5322 116 54188	1M	1	MR30	METAL FILM
R 1254	4822 111 30067	33E	5	CR16	CARBON
R 1256	5322 116 54716	162K	1	MR25	METAL FILM
R 1257	4822 111 30067	33E	5	CR16	CARBON
R 1258	5322 116 50555	1,27K	1	MR25	METAL FILM
R 1302	5322 116 50586	1,54K	1	MR25	METAL FILM
R 1303	5322 116 54532	649E	1	MR25	METAL FILM
R 1304	5322 116 50492	46,4E	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 1306	5322 116 54571	1,96K	1	MR25	METAL FILM
R 1307	5322 116 50572	12,1K	1	MR25	METAL FILM
R 1308	5322 116 50767	2,15K	1	MR25	METAL FILM
R 1309	5322 116 54549	1K	1	MR25	METAL FILM
R 1311	5322 116 50635	1,47K	1	MR25	METAL FILM
R 1312	5322 116 50492	46,4E	1	MR25	METAL FILM
R 1313	5322 116 50492	46,4E	1	MR25	METAL FILM
R 1314	5322 116 54592	4,02K	1	MR25	METAL FILM
R 1316	5322 116 54469	100E	1	MR25	METAL FILM
R 1317	5322 116 54619	10K	1	MR25	METAL FILM
R 1318	5322 116 50492	46,4E	1	MR25	METAL FILM
R 1319	5322 116 50524	3,01K	1	MR25	METAL FILM
R 1321	5322 116 50452	10E	1	MR25	METAL FILM
R 1322	5322 116 54694	90,9K	1	MR25	METAL FILM
R 1323	5322 116 54624	11,5K	1	MR25	METAL FILM
R 1324	5322 116 50581	2,49K	1	MR25	METAL FILM
R 1325	5322 116 54627	13,3K	1	MR25	METAL FILM
R 1326	5322 116 50524	3,01K	1	MR25	METAL FILM
R 1327	4822 110 10035	10K	20	0,05W	CARBON
R 1328	5322 116 50536	464E	1	MR25	METAL FILM
R 1329	5322 116 54619	10K	1	MR25	METAL FILM
R 1330	5322 116 50568	4,99E	1	MR25	METAL FILM
R 1331	5322 116 50442	48,7K	1	MR25	METAL FILM
R 1332	5322 116 50442	48,7K	1	MR25	METAL FILM
R 1333	4822 110 63187	1M	5	CR25	CARBON
R 1334	4822 110 63187	1M	5	CR25	CARBON
R 1336	5322 116 54525	511E	1	MR25	METAL FILM
R 1337	4822 110 63161	100K	5	CR25	CARBON
R 1338	4822 110 42189	1,2M	5	VR37	CARBON
R 1339	4822 110 42196	2,2M	5	VR37	CARBON
R 1340	5322 116 54071	10,5E	1	MR25	METAL FILM
R 1341	4822 110 42207	5,6M	5	VR37	CARBON
R 1342	4822 110 60158	82K	5	CR25	CARBON
R 1343	4822 110 60168	200K	5	CR25	CARBON
R 1344	4822 100 10052	100K	20	0,05W	CARBON TRIMMING POTM
R 1346	4822 100 10089	1M	20	0,05W	CARBON TRIMMING POTM
R 1347	4822 110 63163	120K	5	CR25	CARBON
R 1348	4822 110 63176	390K	5	CR25	CARBON
R 1349	5322 116 54696	100K	1	MR25	METAL FILM
R 1350	5322 116 54696	100K	1	MR25	METAL FILM
R 1351	5322 116 54069	12,1E	1	MR25	METAL FILM
R 1352	5322 116 54069	12,1E	1	MR25	METAL FILM
R 1353	5322 116 50676	196E	1	MR25	METAL FILM
R 1354	5322 116 54516	365E	1	MR25	METAL FILM
R 1361	5322 116 54469	100E	1	MR25	METAL FILM
R 1362	5322 100 10114	4,7K	20	0,5W	CARBON TRIMMING POTM
R 1363	5322 116 54576	2,37K	1	MR25	METAL FILM
R 1364	5322 116 50608	6,19K	1	MR25	METAL FILM
R 1366	5322 116 54533	665E	1	MR25	METAL FILM
R 1367	5322 116 55008	499E	0,1	MR24E	METAL FILM
R 1368	5322 116 54639	19,1K	1	MR25	METAL FILM
R 1369	5322 116 54502	261E	1	MR25	METAL FILM
R 1371	5322 116 50608	6,19K	1	MR25	METAL FILM
R 1372	5322 116 54469	100E	1	MR25	METAL FILM
R 1401	5322 116 54665	40,2K	1	MR25	METAL FILM
R 1402	5322 116 50442	48,7K	1	MR25	METAL FILM
R 1403	5322 116 54683	68,1K	1	MR25	METAL FILM
R 1404	5322 116 50474	42,2K	1	MR25	METAL FILM
R 1406	5322 116 54549	1K	1	MR25	METAL FILM
R 1407	5322 116 54696	100K	1	MR25	METAL FILM
R 1408	5322 116 54632	14,7K	1	MR25	METAL FILM
R 1409	5322 116 50672	51,1K	1	MR25	METAL FILM
R 1416	5322 111 50345	8,2M	5	1W	CARBON
R 1601	5322 116 54466	90,9E	1	MR25	METAL FILM
R 1602	5322 116 54466	90,9E	1	MR25	METAL FILM
R 1603	5322 116 50417	162E	1	MR25	METAL FILM
R 1604	5322 116 50675	2,26K	1	MR25	METAL FILM
R 1606	5322 116 50675	2,26K	1	MR25	METAL FILM
R 1607	5322 116 50586	1,54K	1	MR25	METAL FILM
R 1608	5322 116 50636	2,74K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R 1609	5322 116 50636	2,74K	1	MR25	METAL FILM
R 1611	5322 116 50636	2,74K	1	MR25	METAL FILM
R 1612	5322 116 50636	2,74K	1	MR25	METAL FILM
R 1613	5322 116 50636	2,74K	1	MR25	METAL FILM
R 1614	5322 116 50636	2,74K	1	MR25	METAL FILM
R 1616	5322 116 50568	4,99E	1	MR25	METAL FILM
R 1617	5322 116 50452	10E	1	MR25	METAL FILM
R 1800	4822 110 63041	3,3E	5	CR25	CARBON
R 1801	5322 113 60064	2,7E	10	2W	WIRE-WOUND
R 1802	5322 116 54643	20,5K	1	MR25	METAL FILM
R 1803	5322 116 54696	100K	1	MR25	METAL FILM
R 1804	5322 116 54696	100K	1	MR25	METAL FILM
R 1805	5322 116 54549	1K	1	MR25	METAL FILM
R 1806	4822 110 63198	2,7M	10	CR25	CARBON
R 1807	5322 116 54005	3,32K	1	MR25	METAL FILM
R 1811	4822 110 63041	3,3E	5	CR25	CARBON
R 1814	5322 116 50766	147E	1	MR25	METAL FILM
R 1815	5322 116 50557	46,4K	1	MR25	METAL FILM
R 1816	5322 116 50484	4,64K	1	MR25	METAL FILM
R 1818	5322 116 50417	162E	1	MR25	METAL FILM
R 1819	4822 111 30315	2,2E	5	CR37	CARBON
R 1820	5322 116 34028	150K	5	0,5W	NTC
R 1821	5322 116 54035	24,9K	1	MR30	METAL FILM
R 1822	5322 116 54549	1K	1	MR25	METAL FILM
R 1824	5322 116 50731	10,5K	1	MR25	METAL FILM
R 1826	5322 116 54557	1,21K	1	MR25	METAL FILM
R 1827	5322 116 54564	1,5K	1	MR25	METAL FILM
R 1828	5322 116 50636	2,74K	1	MR25	METAL FILM
R 1829	5322 116 50767	2,15K	1	MR25	METAL FILM
R 1830	5322 116 54619	10K	1	MR25	METAL FILM
R 1831	5322 116 54549	1K	1	MR25	METAL FILM
R 1832	5322 116 54558	8,25K	1	MR25	METAL FILM
R 1833	5322 116 50515	1,78K	1	MR25	METAL FILM
R 1834	5322 101 14057	1K	20	0,05W	CARBON TRIMMING POTM
R 1835	5322 116 54192	5,11E	1	MR25	METAL FILM
R 1836	5322 116 54558	8,25K	1	MR25	METAL FILM
R 1837	4822 110 63178	470K	5	CR25	CARBON
R 1838	5322 116 54689	82,5K	1	MR25	METAL FILM
R 1839	5322 116 54592	4,02K	1	MR25	METAL FILM
R 1841	5322 100 10154	500K	20		CARBON TRIMMING POTM
R 1842	5322 116 54655	30,1K	1	MR25	METAL FILM
R 1843	5322 116 54643	20,5K	1	MR25	METAL FILM
R 1844	5322 116 54643	20,5K	1	MR25	METAL FILM
R 1845	5322 116 54525	511E	1	MR25	METAL FILM
R 1846	5322 116 54696	100K	1	MR25	METAL FILM
R 1847	5322 116 54469	100E	1	MR25	METAL FILM
R 1848	5322 116 54469	100E	1	MR25	METAL FILM
R 1849	5322 116 54619	10K	1	MR25	METAL FILM
R 1851	5322 116 54648	24,9K	1	MR25	METAL FILM

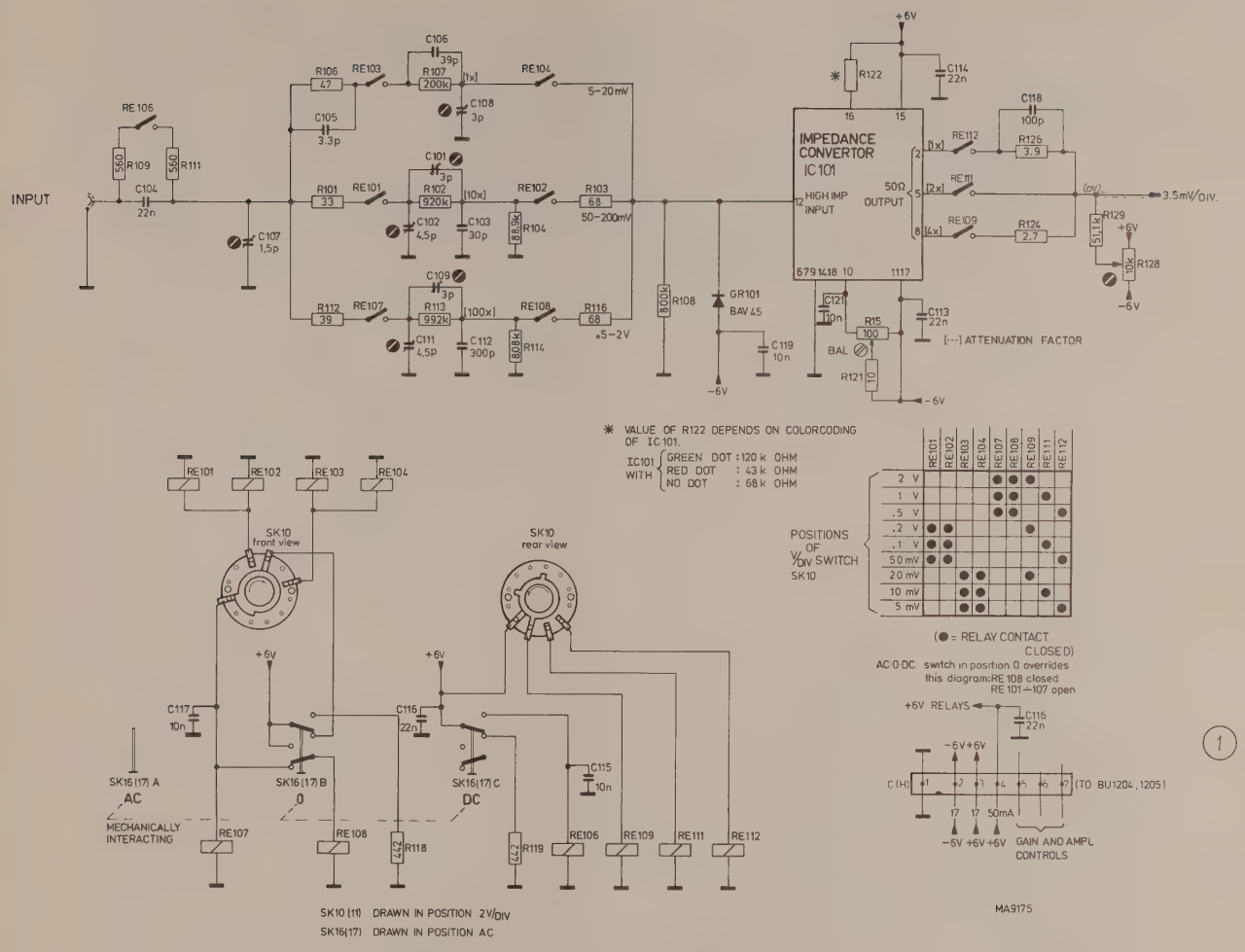


Fig. 3.20. Y-attenuator circuit diagram

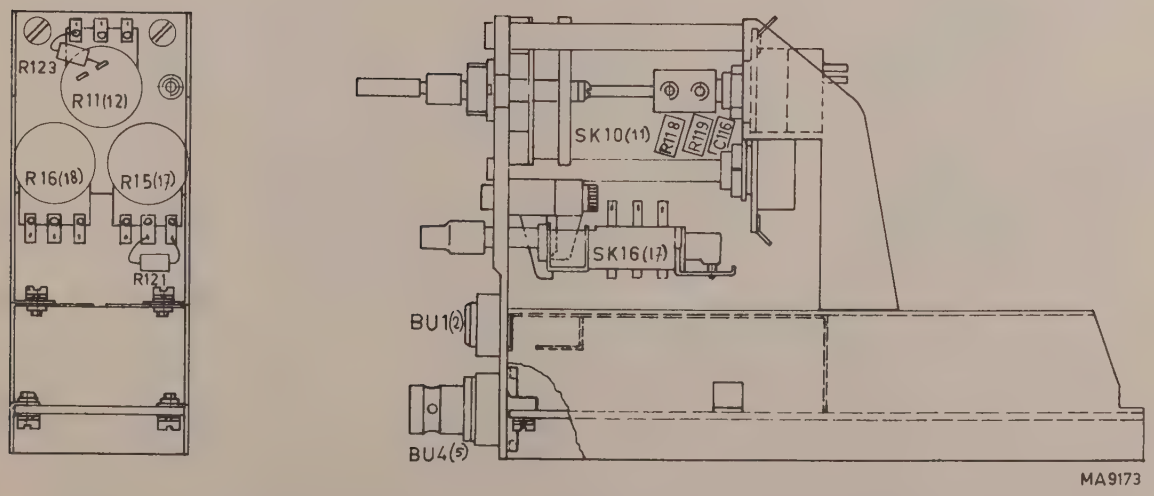


Fig. 3.21. Y-attenuator assembly

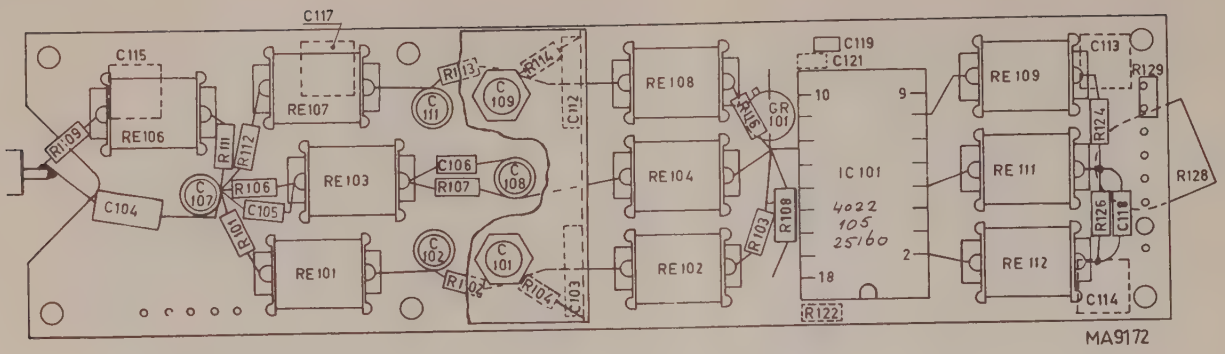


Fig. 3.22. Y-attenuator p.c. board

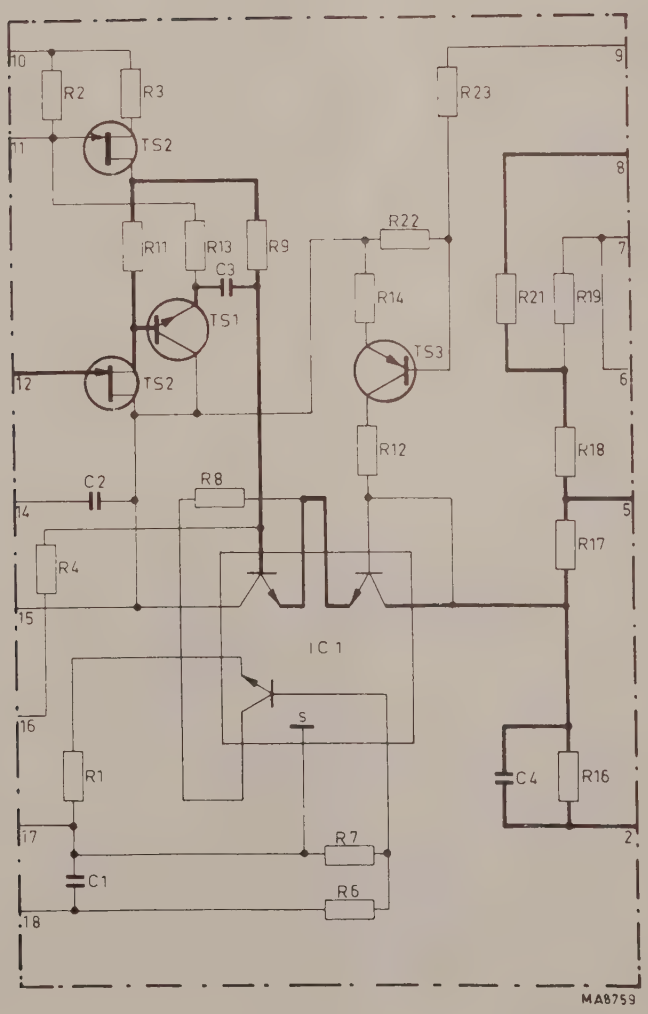


Fig. 3.23. Circuit diagram attenuator impedance converter

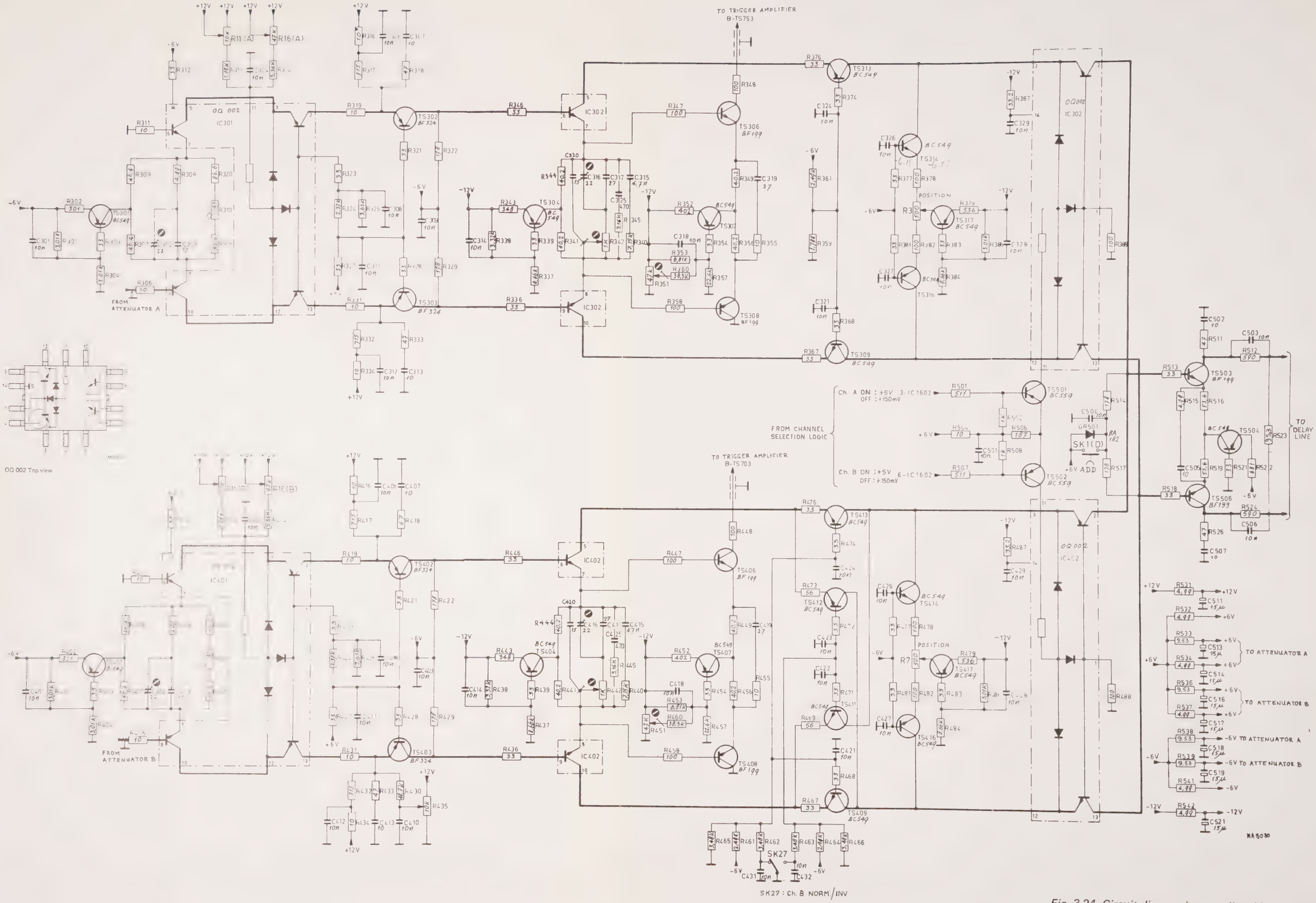


Fig. 3.24. Circuit diagram intermediate Y amplifier

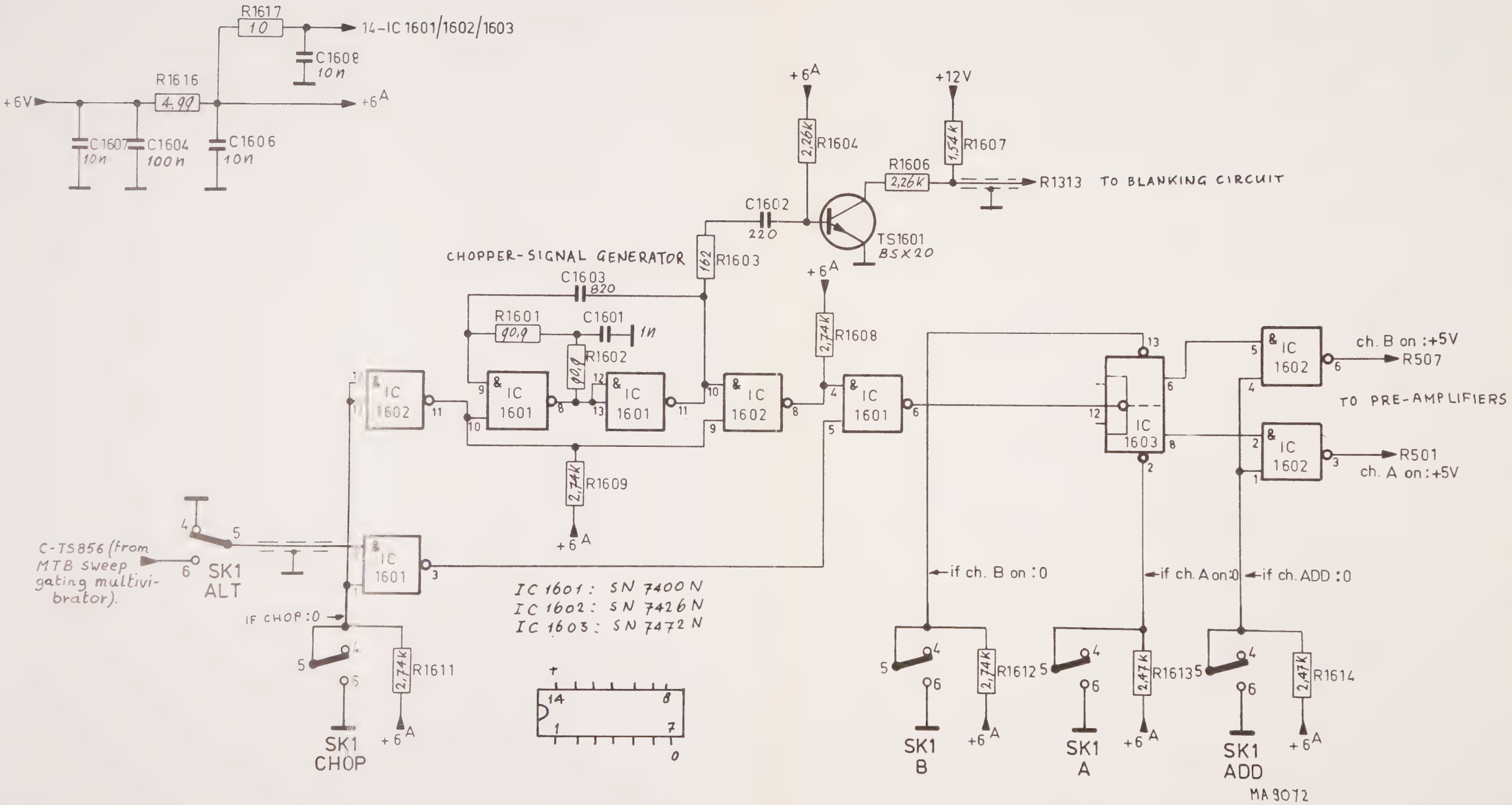


Fig. 3.25. Circuit diagram channel selection logic

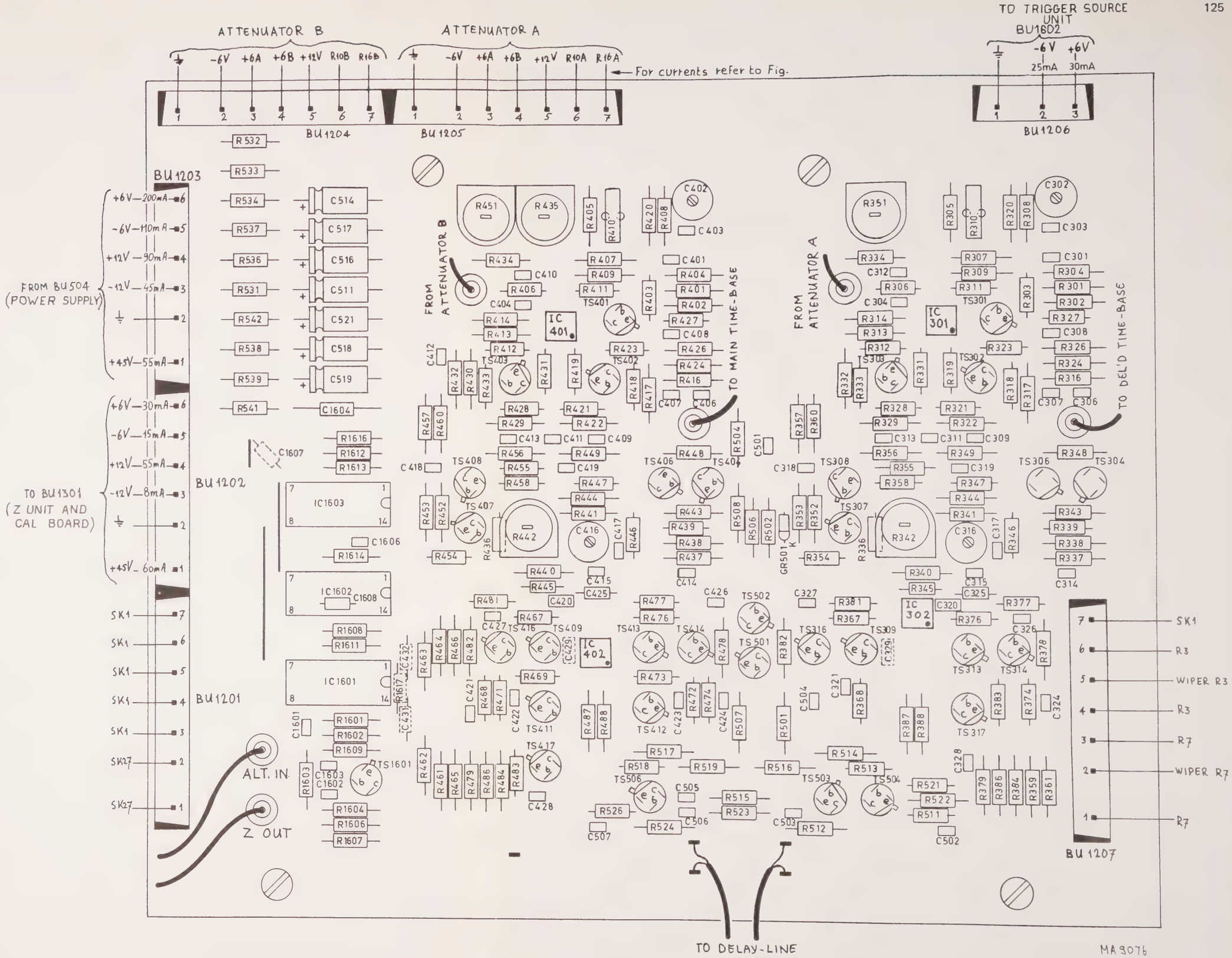


Fig. 3.26. Intermediate Y amplifier p.c. board

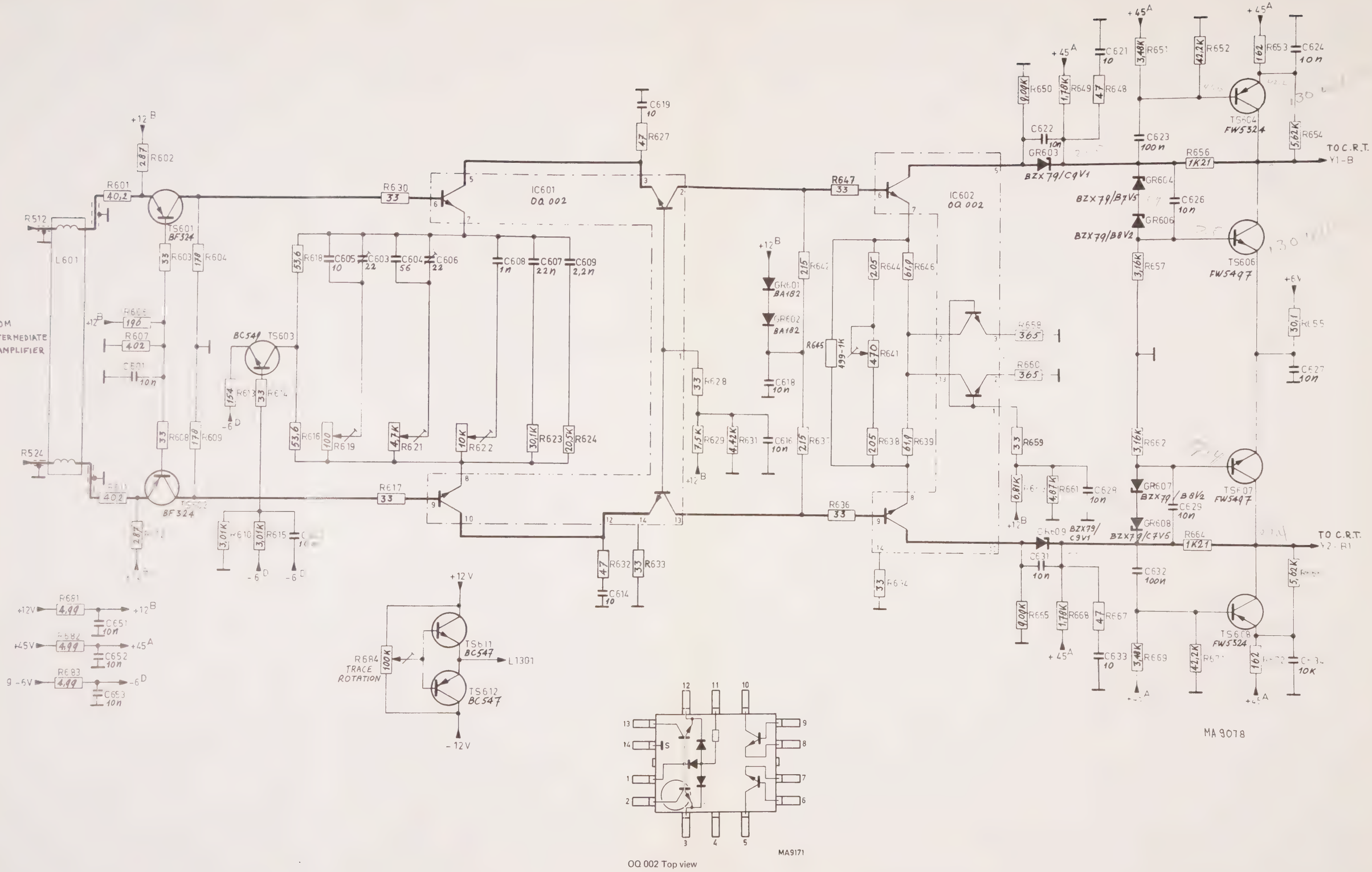


Fig. 3.27. Circuit diagram final Y amplifier

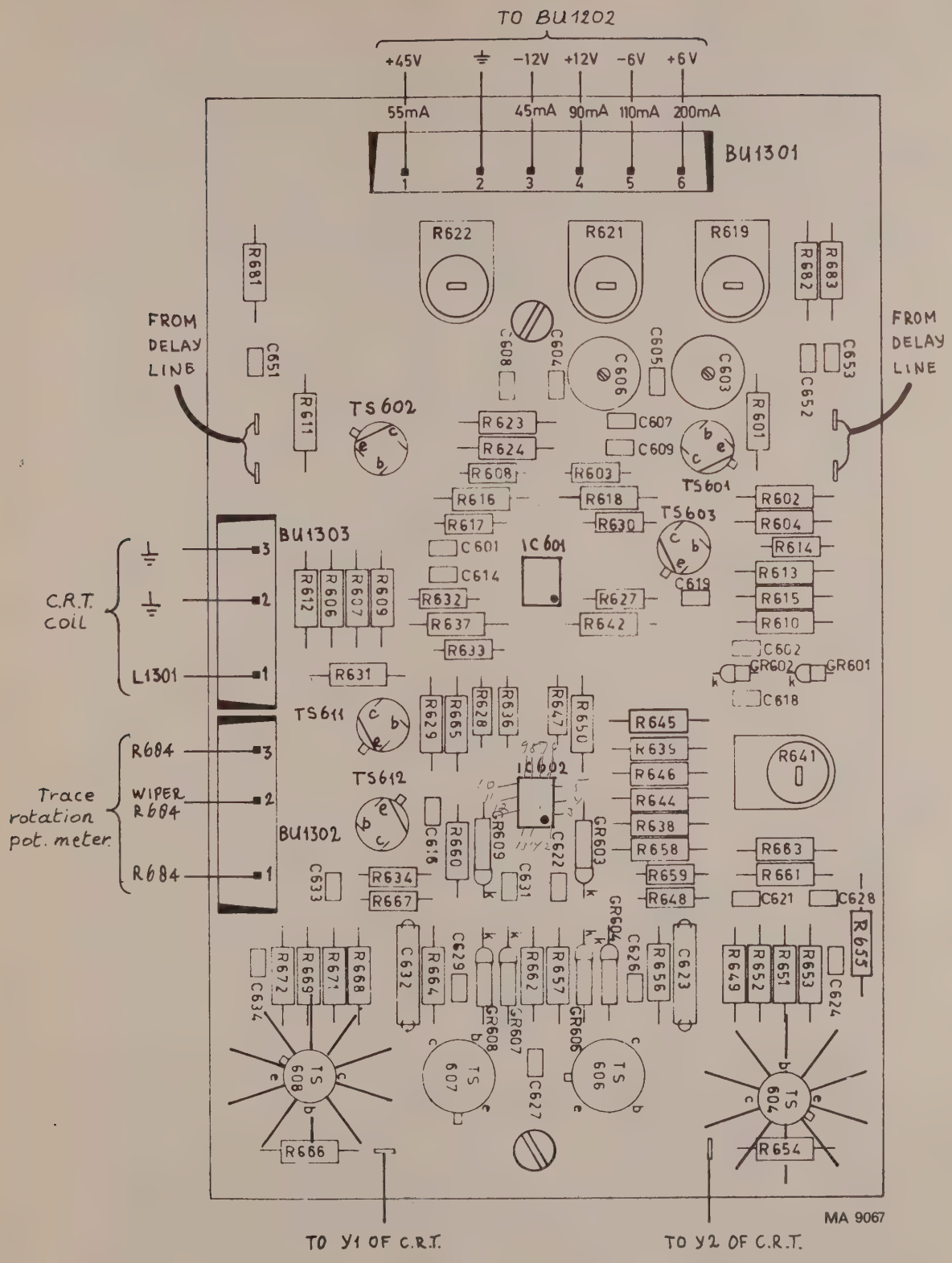


Fig. 3.28. Final Y amplifier p.c. board

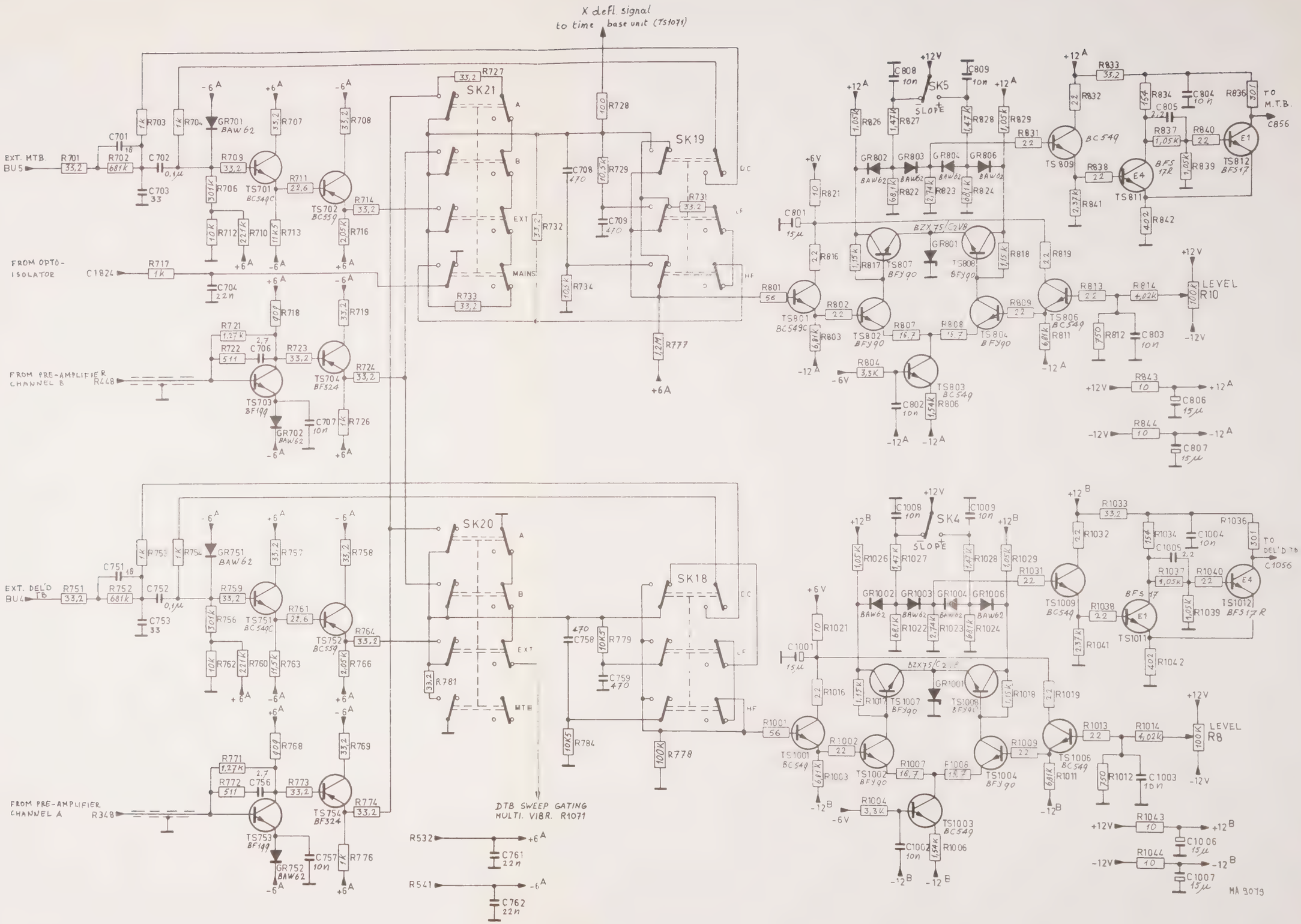


Fig. 3.29. Circuit diagram trigger unit

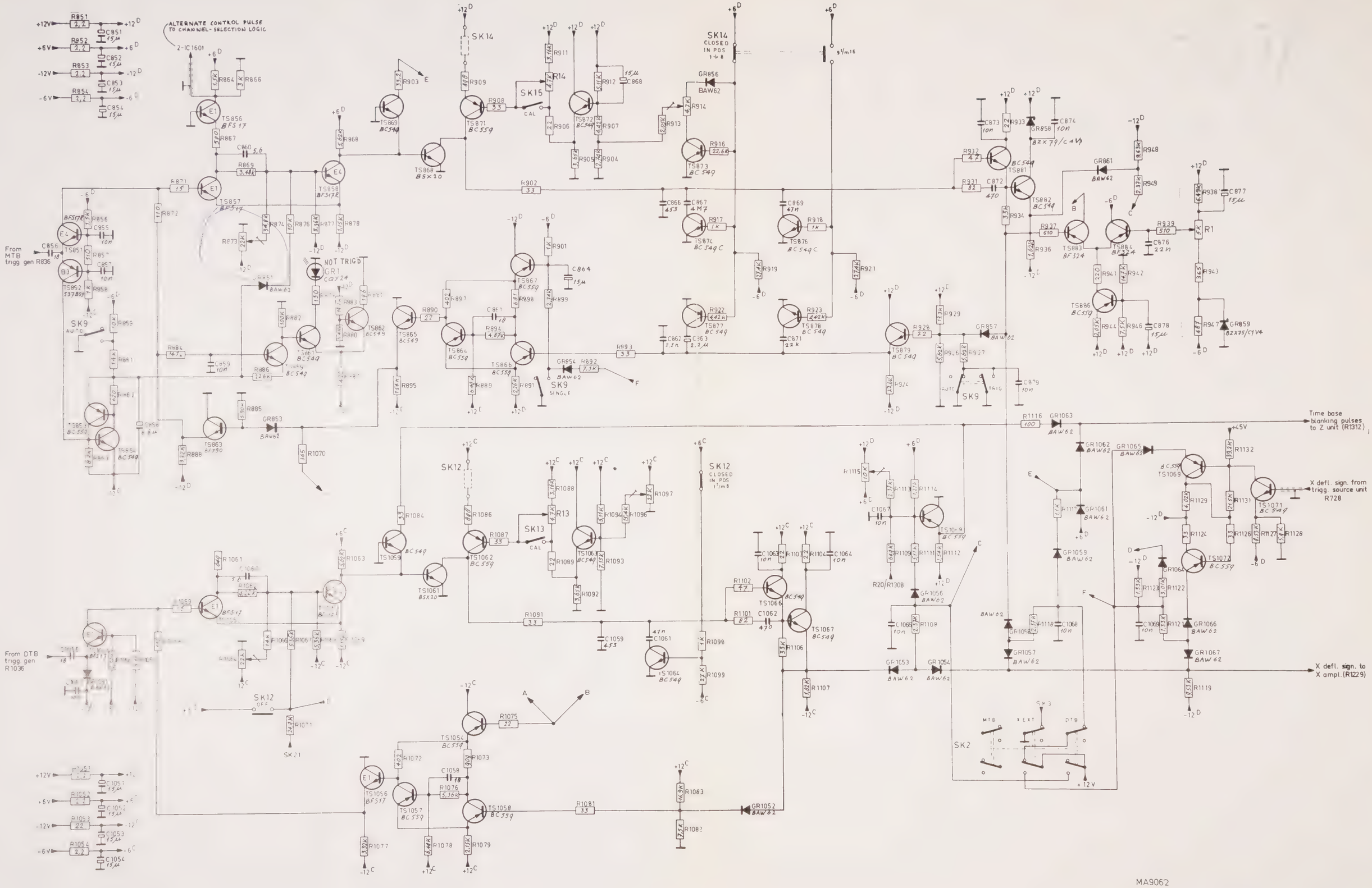

ALTERNATE CONTROL PULSE TO CHANNEL-SELECTION LOGIC
From MTB trigg. gen R836
From DTB trigg. gen R1036
SK14 CLOSED IN POS 1÷8
SK15 CAL
SK13 CAL
SK12 CLOSED IN POS 1÷8
SK12 OFF
SK9 AUTO
SK9 SINGLE
SK9 AUTO TRIG
SK2 MTB XEXT DTB
NOT TRIGD
Time base blanking pulses to Z unit (R1312)
X defl. sign. from trigg. source unit R728
X defl. sign. to X ampl. (R1229)
MA9062

Fig. 3.30. Circuit diagram time-base unit

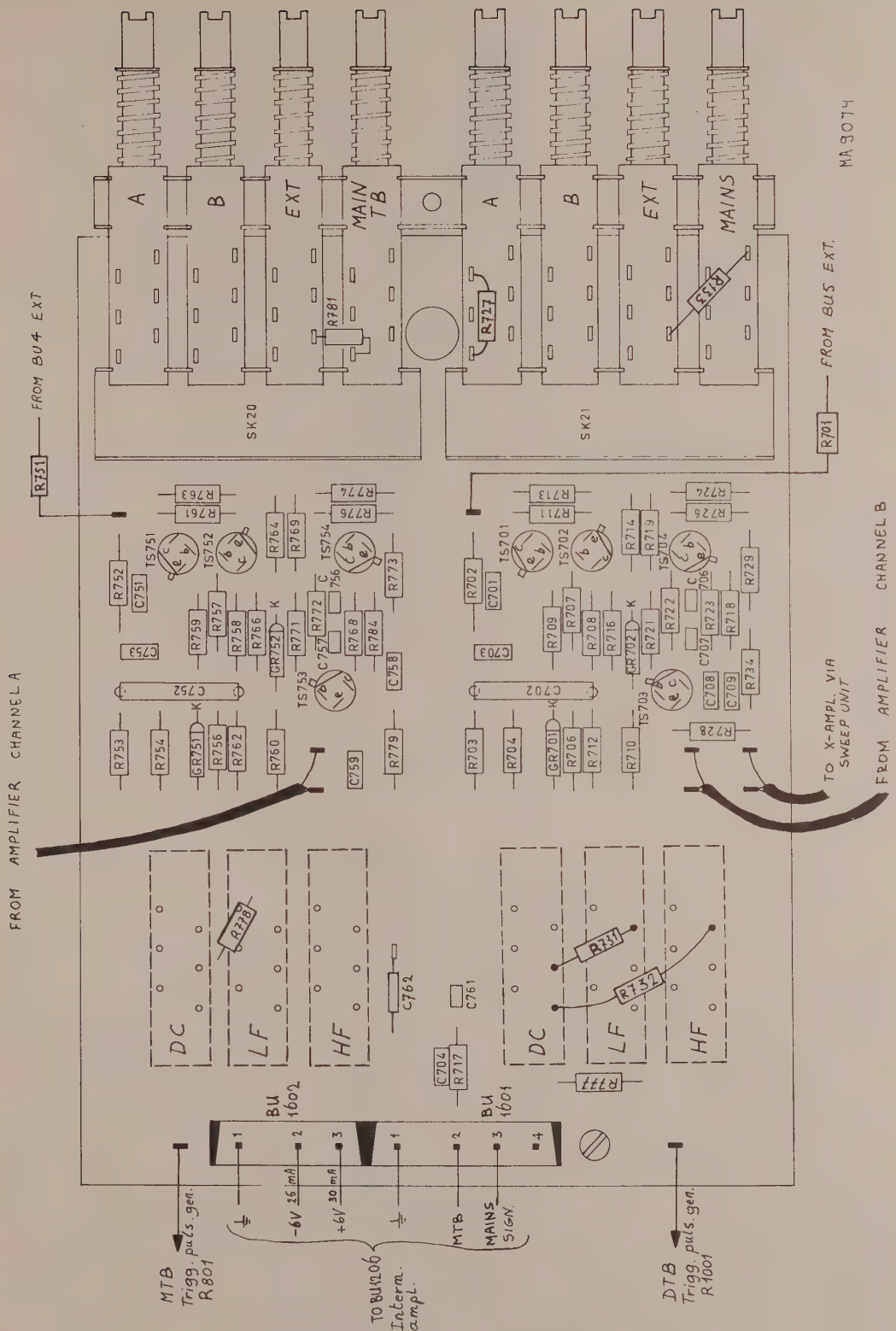


Fig. 3.31. Trigger unit p.c. board

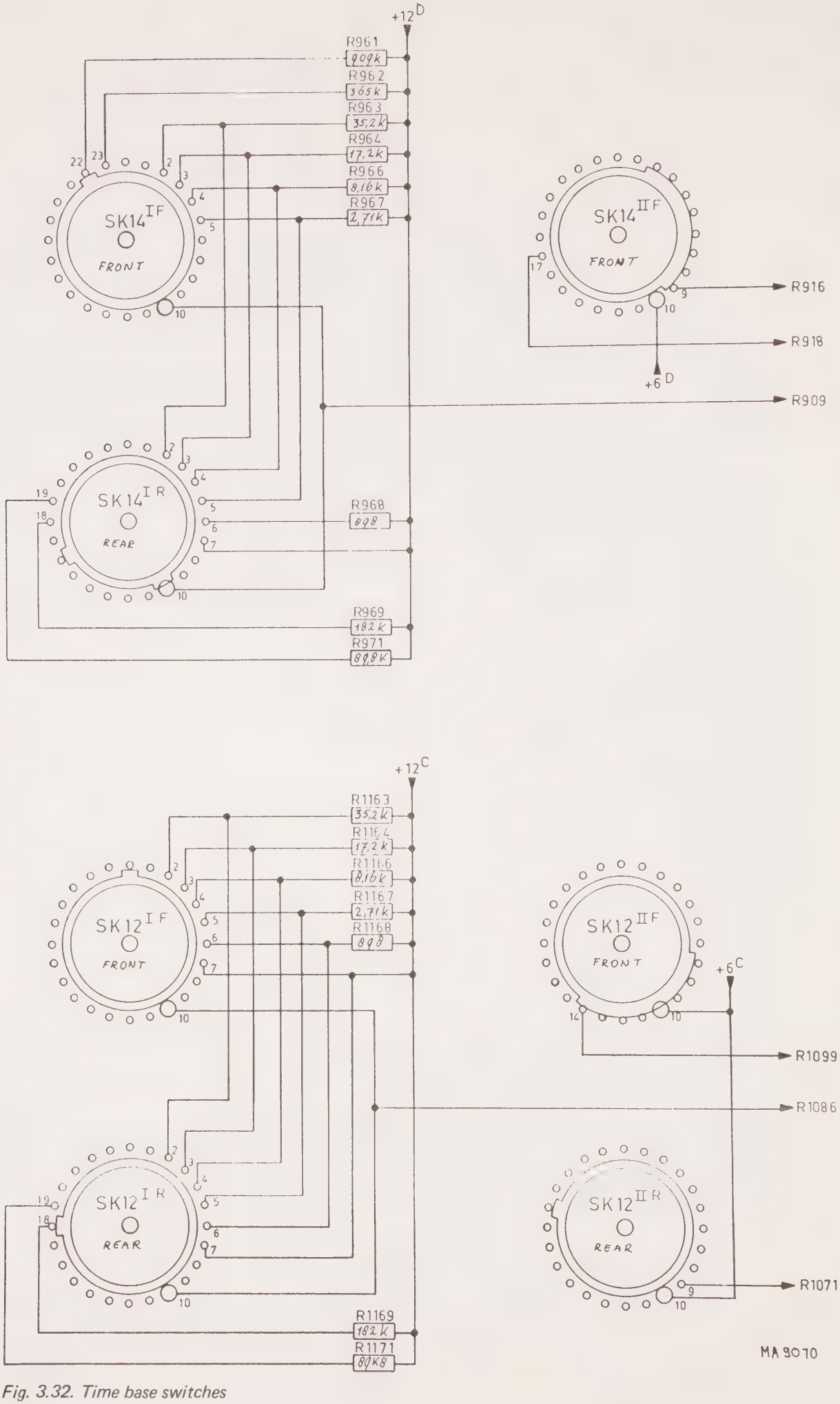


Fig. 3.32. Time base switches

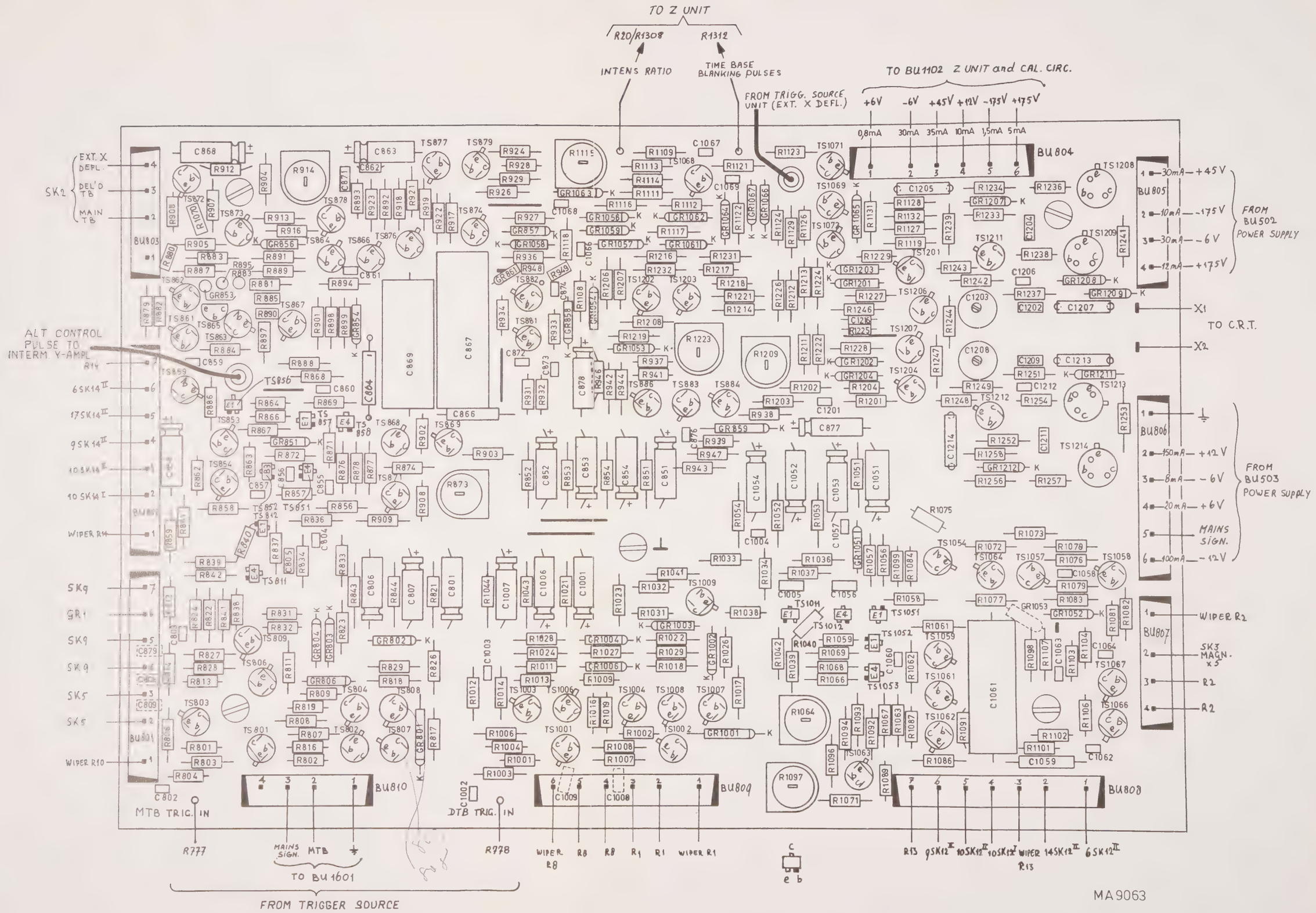


Fig. 3.33. Time base and X-amplifier p.c. board

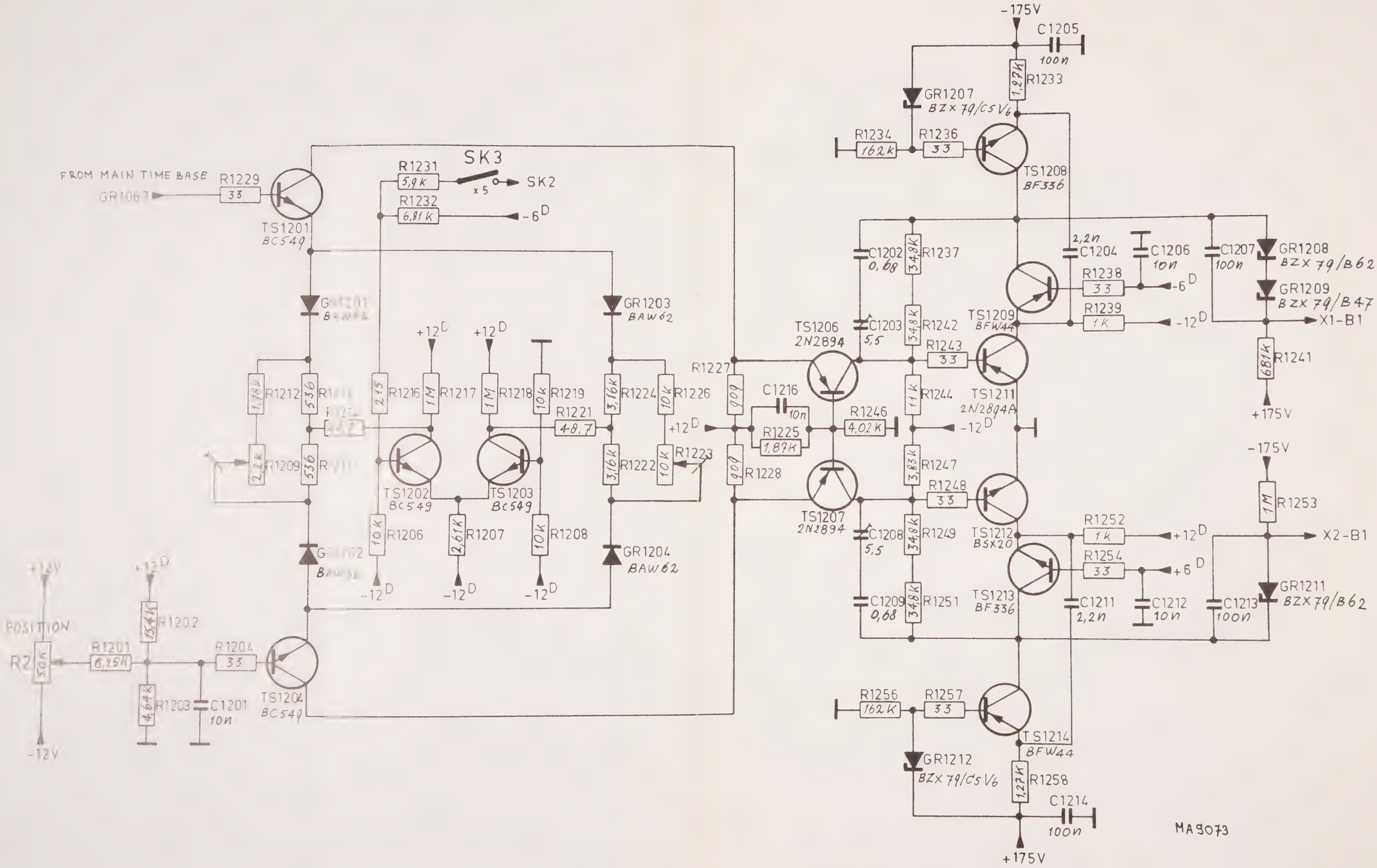
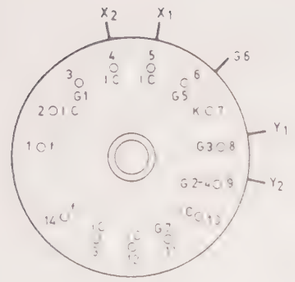
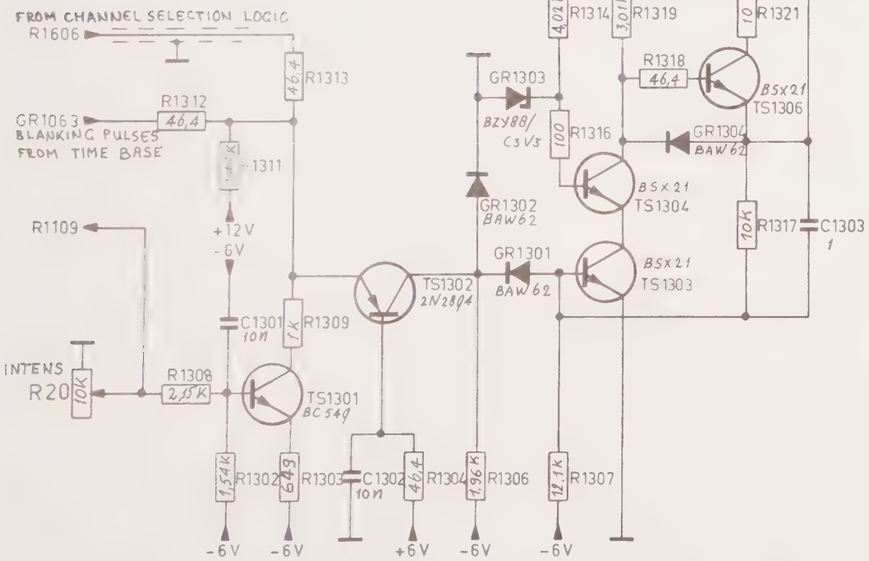
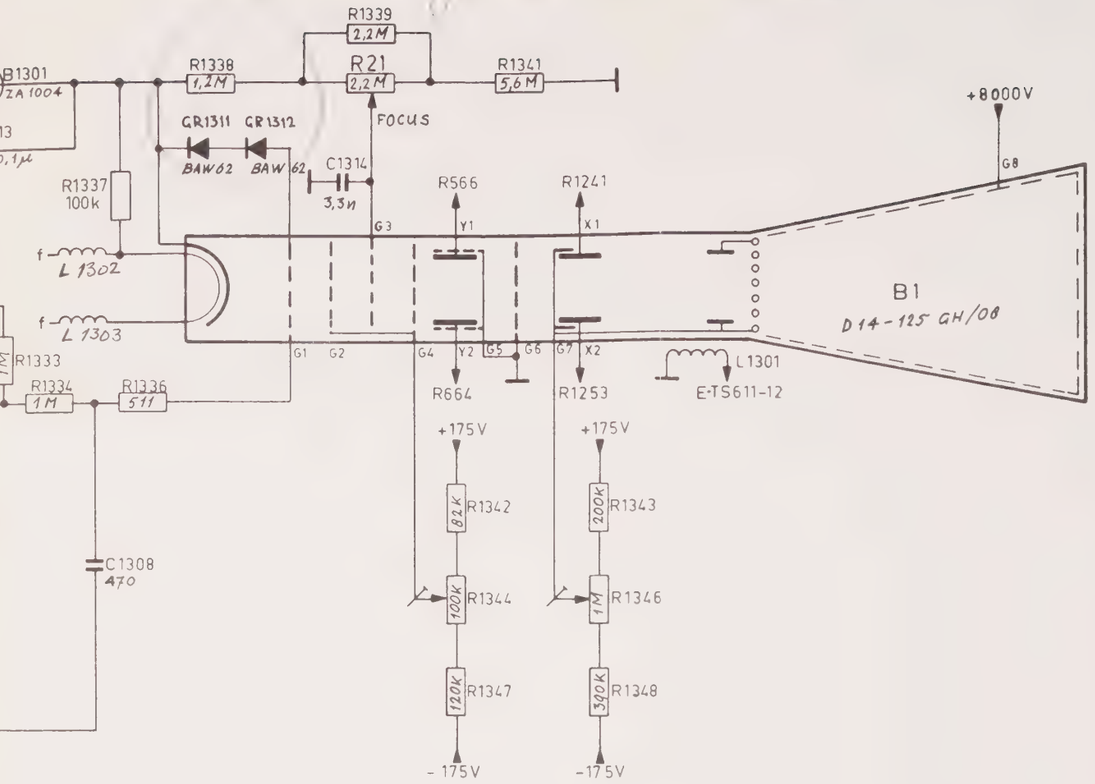
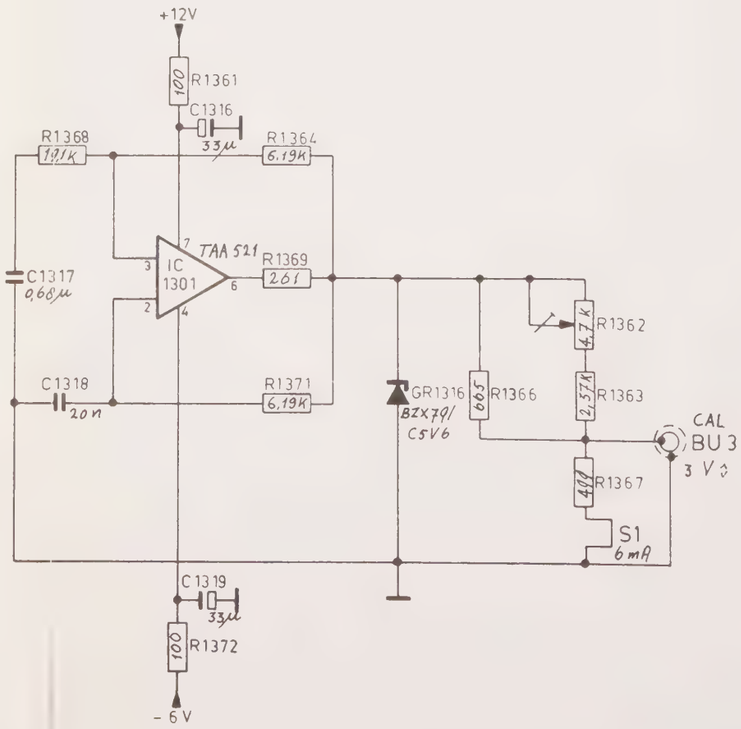


Fig. 3.34. Circuit diagram X amplifier









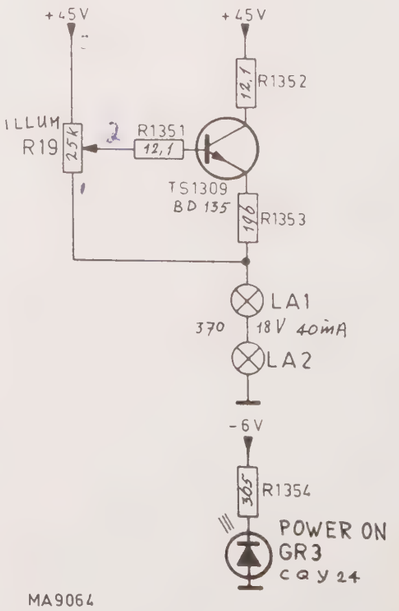


Fig. 3.35. Circuit diagram Z unit and calibration unit

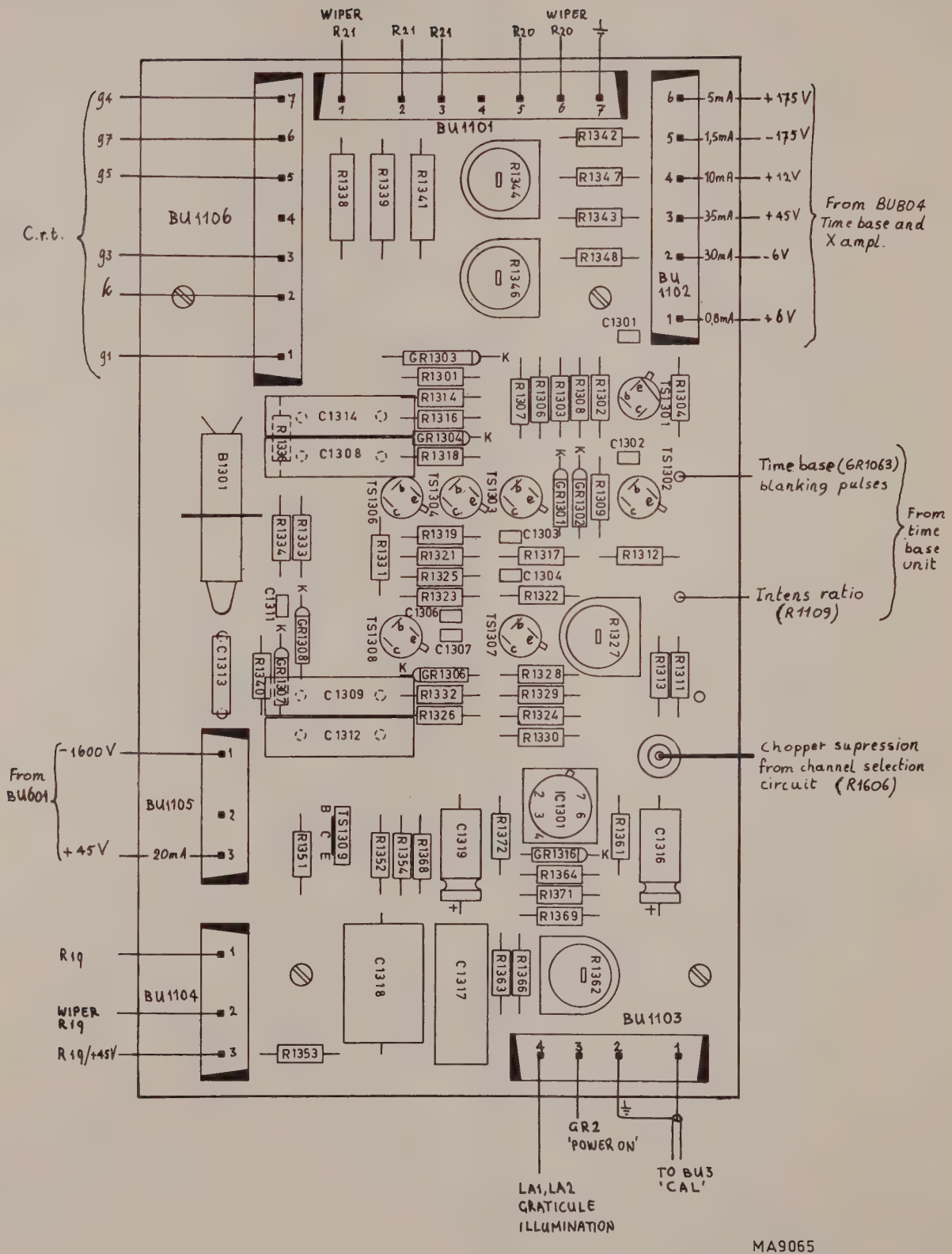


Fig. 3.36. Z unit and calibration unit p.c. board

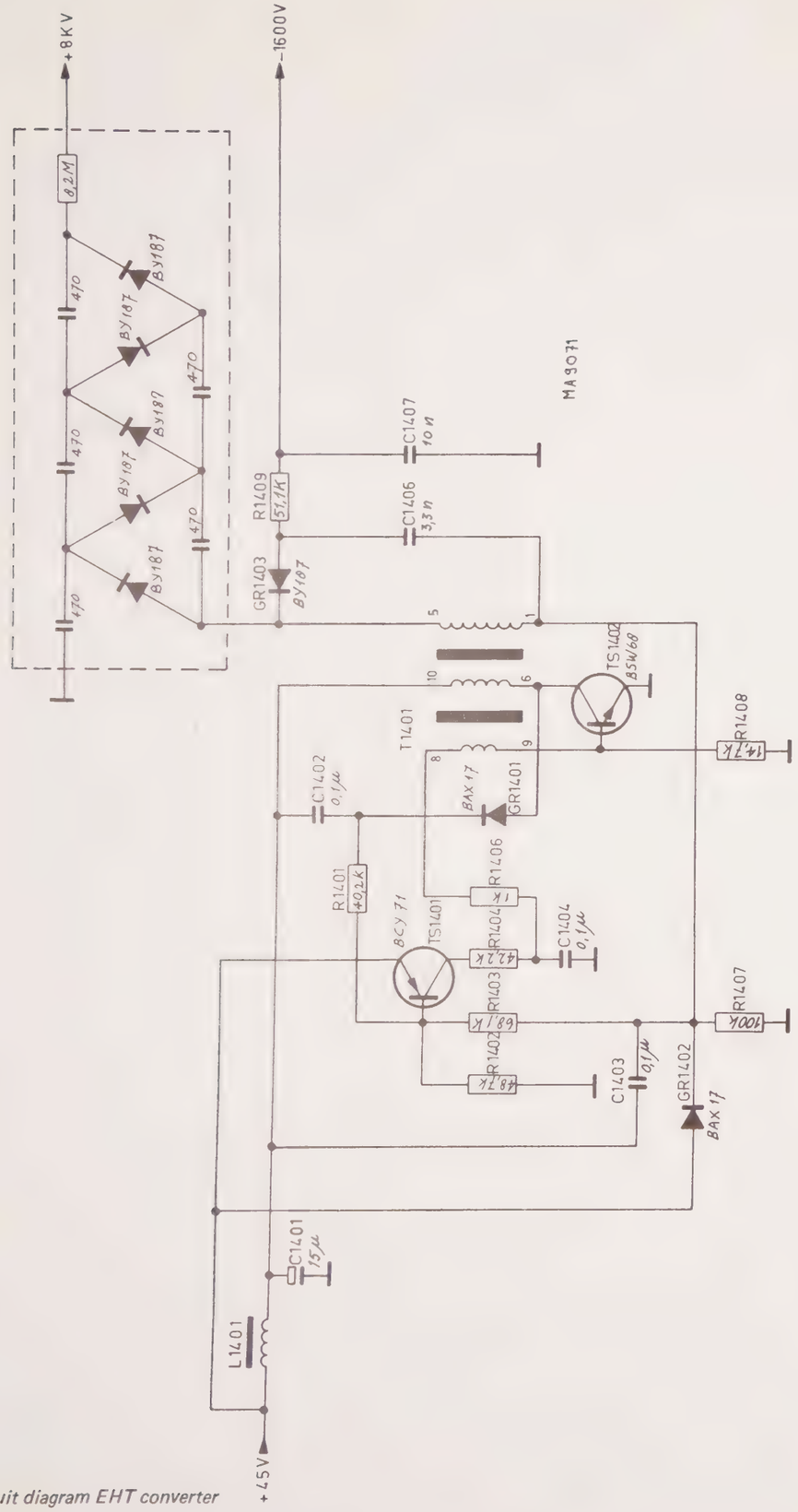


Fig. 3.37. Circuit diagram EHT converter

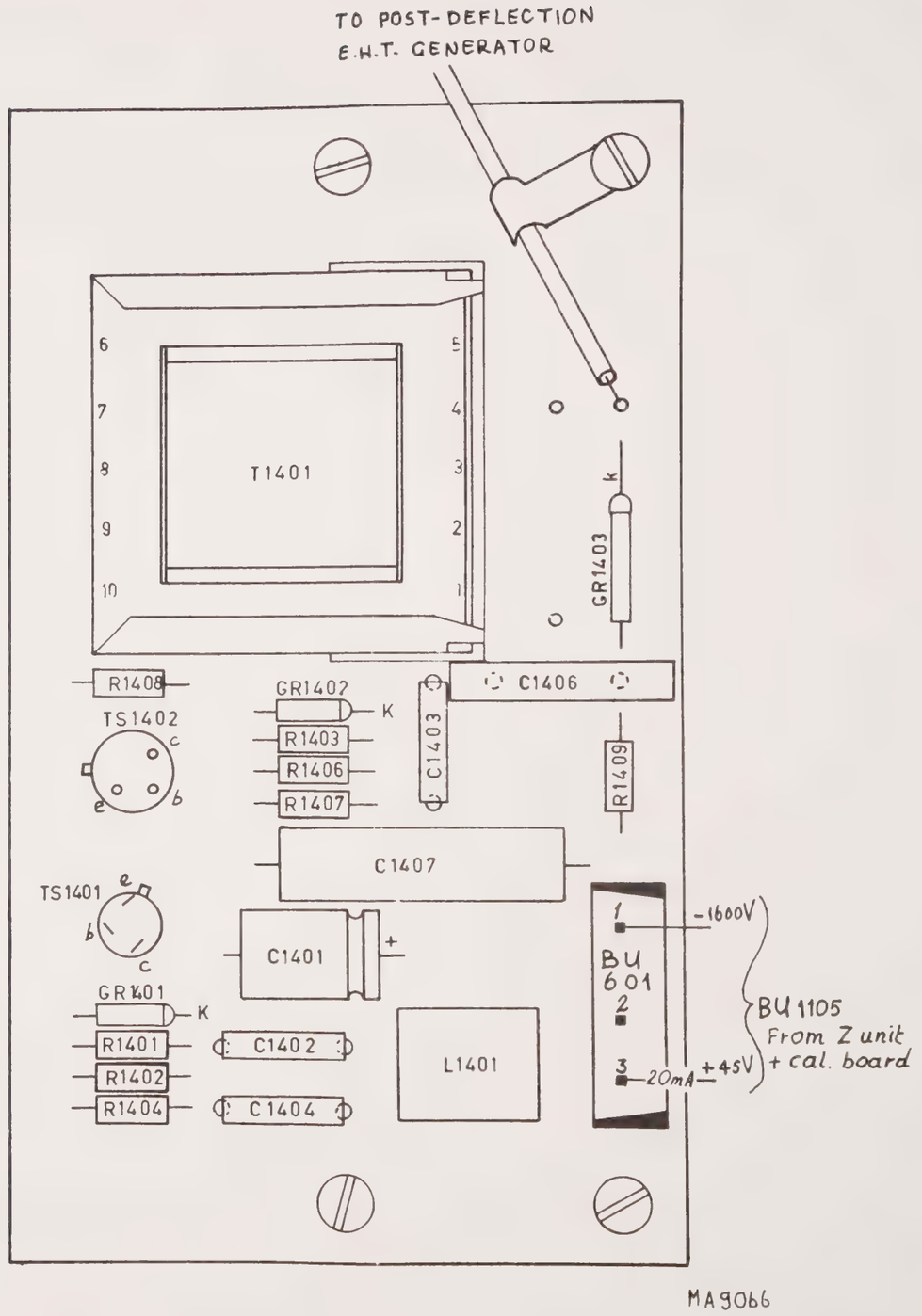


Fig. 3.38. EHT converter p.c. board

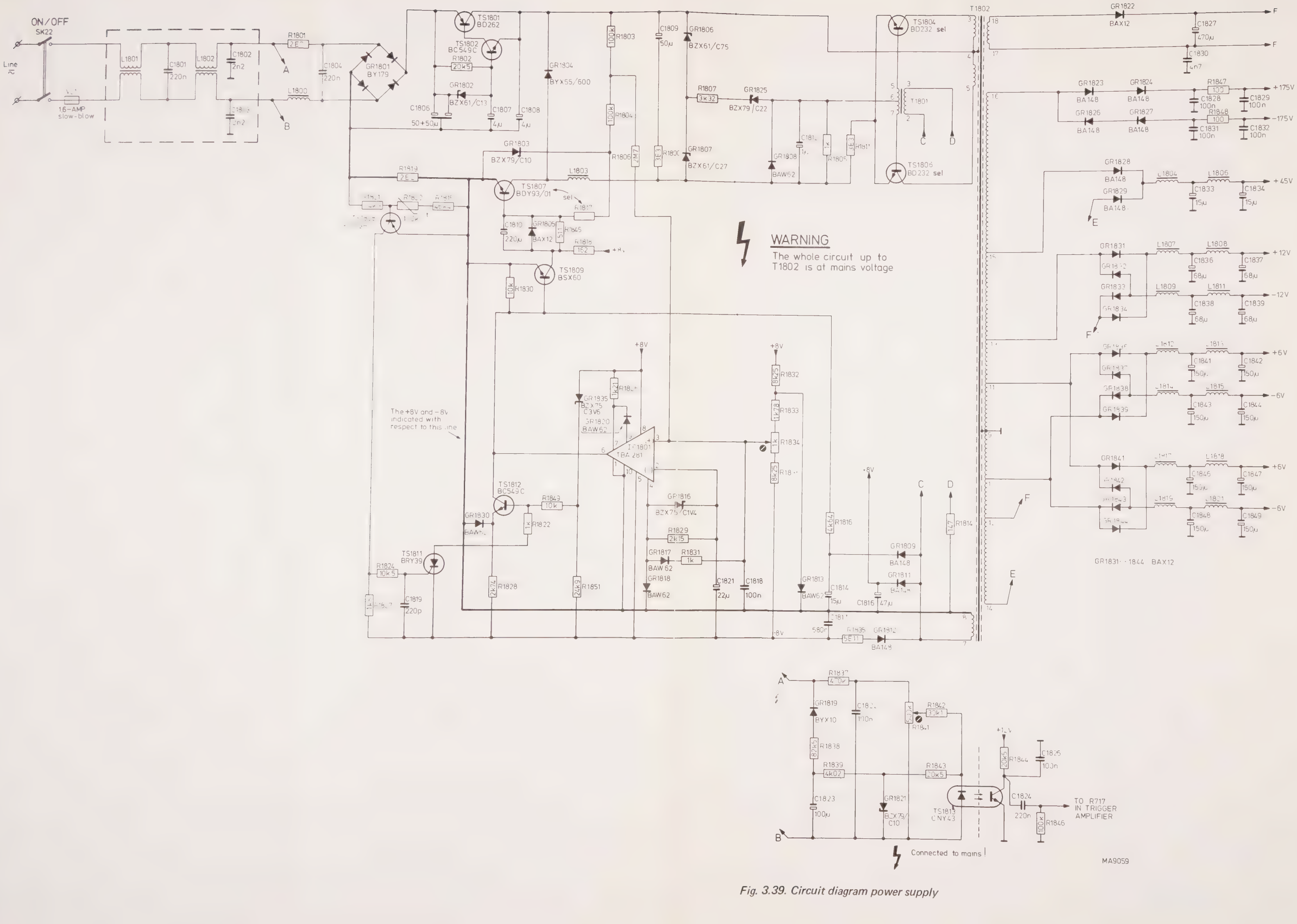
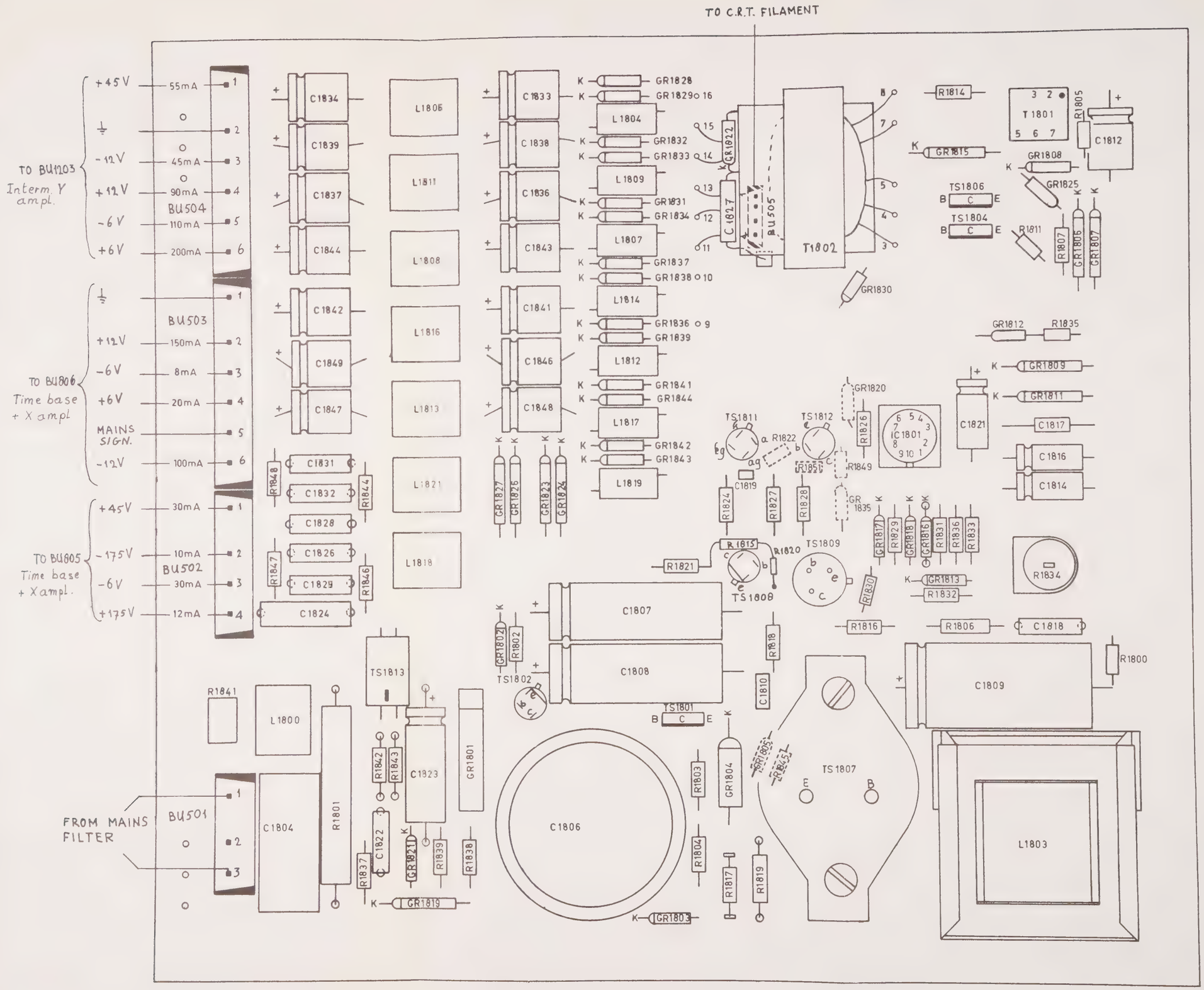


Fig. 3.39. Circuit diagram power supply



MA 9075

Fig. 3.40. Power supply p.c. board

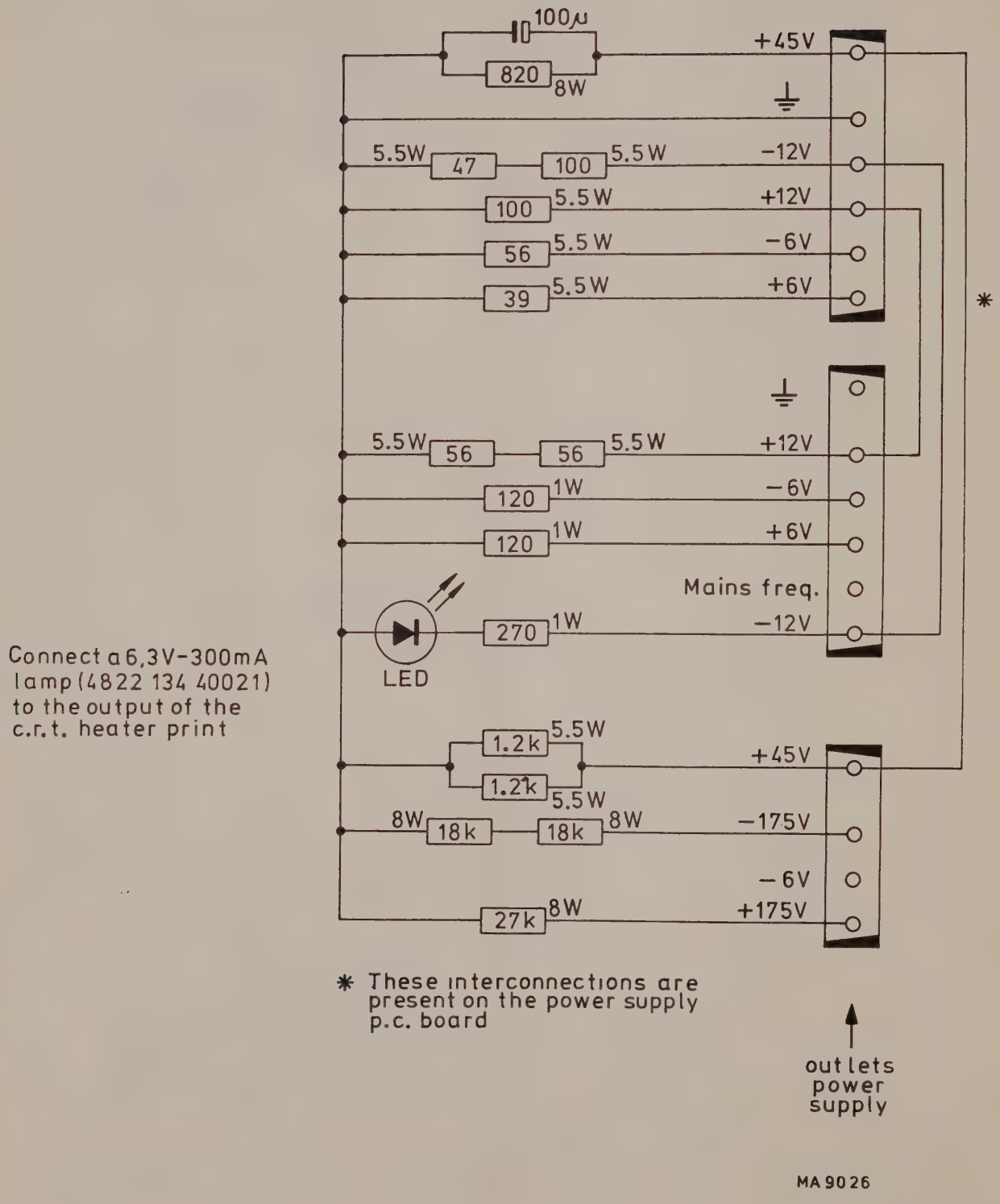


Fig. 3.41. Dummy load for power supply

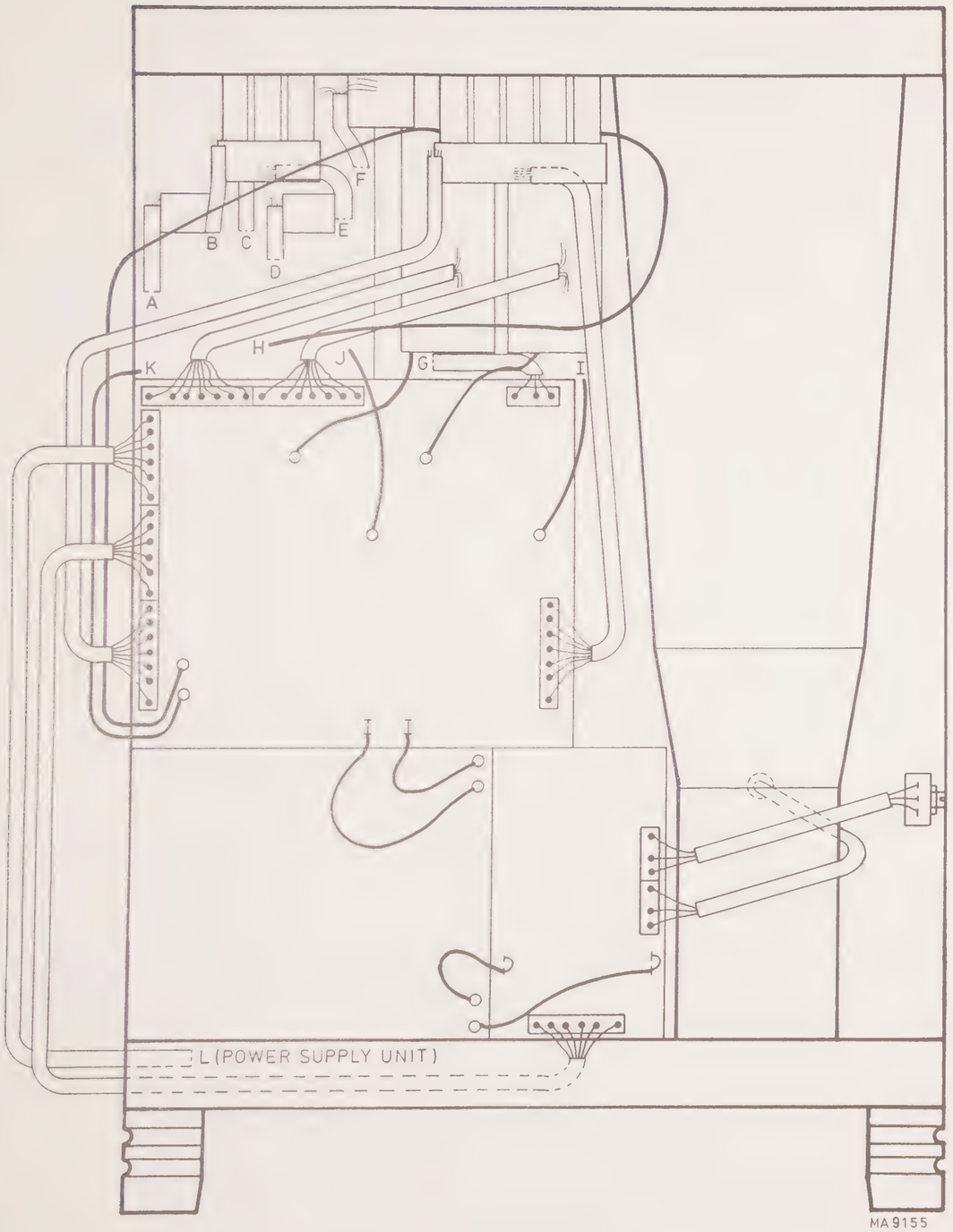


Fig. 3.42. Cable lay-out, top view

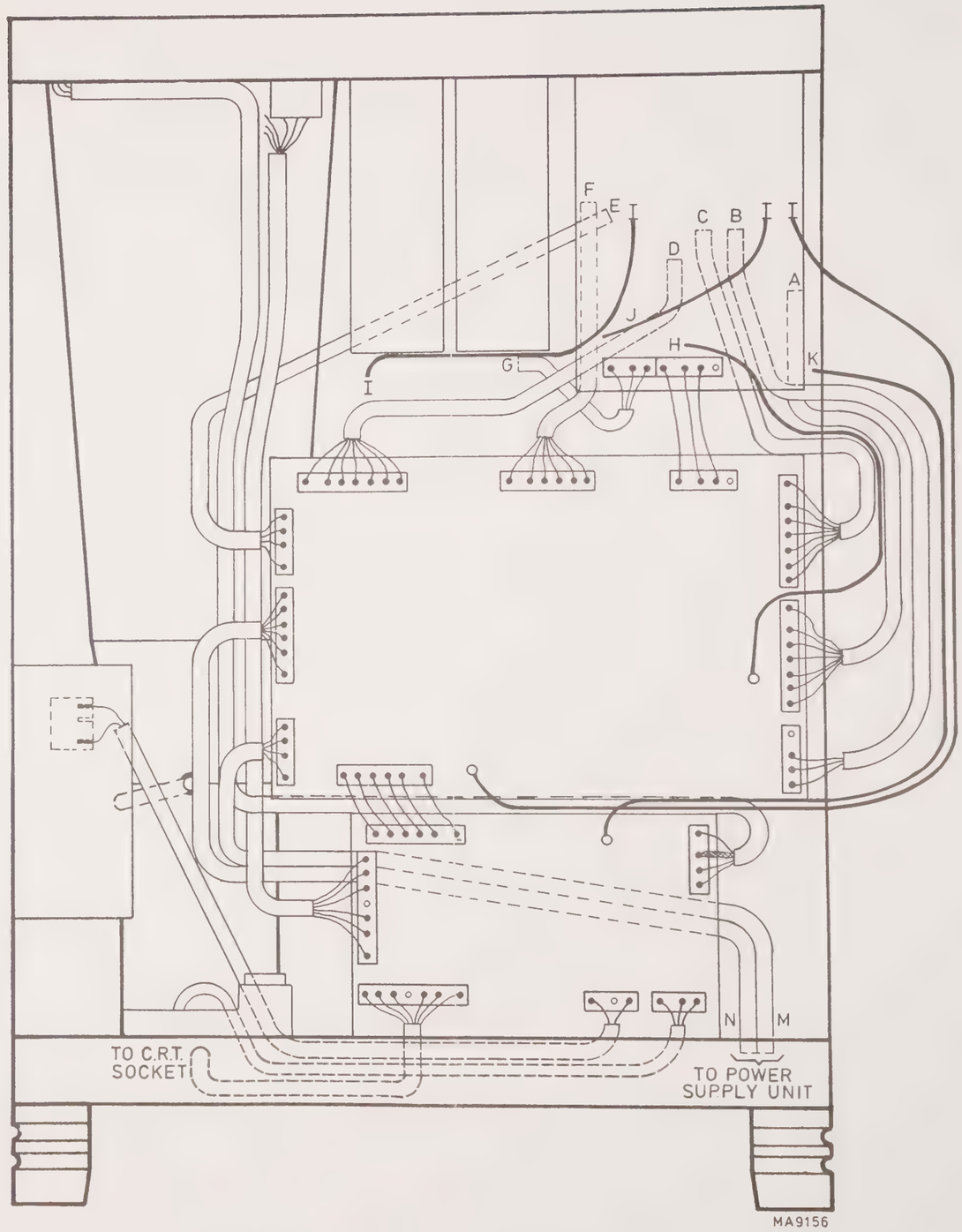


Fig. 3.43. Cable lay-out, bottom view

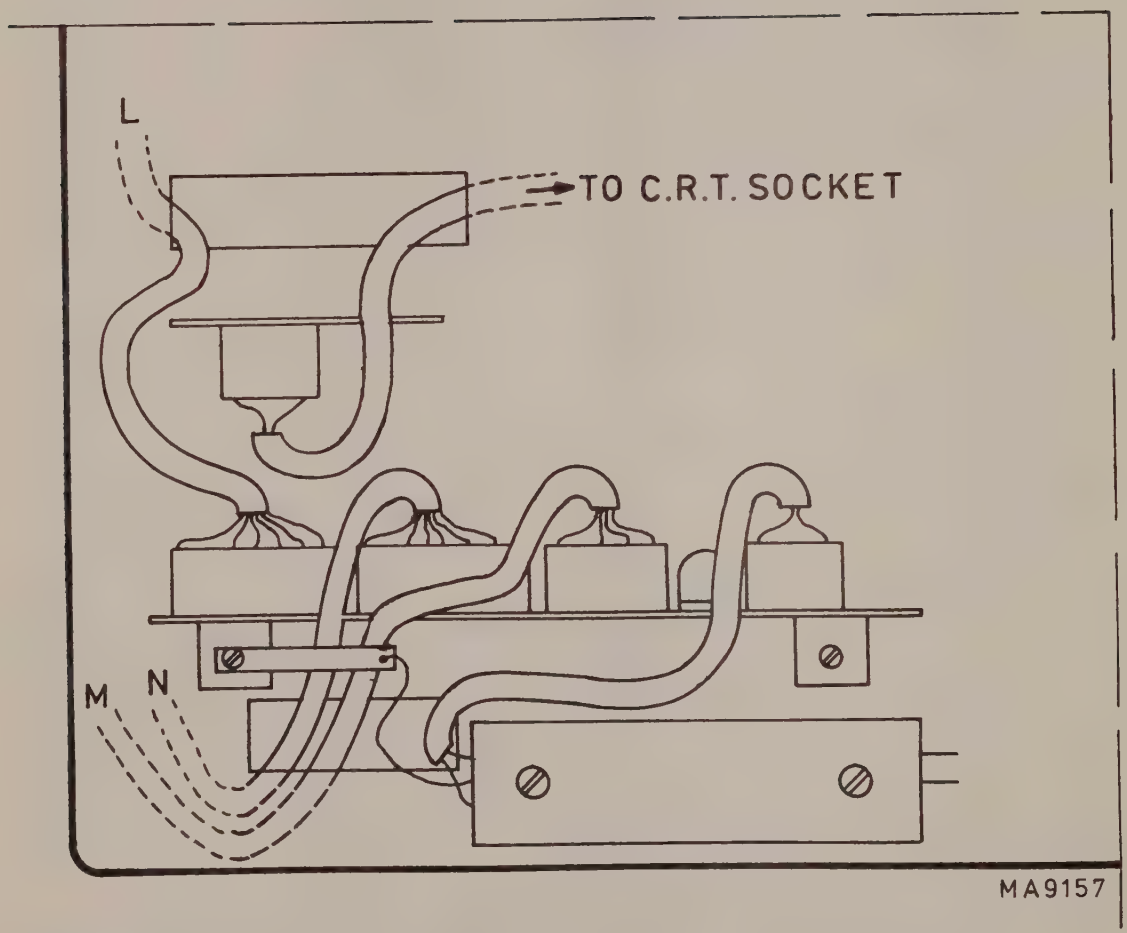


Fig. 3.44. Cable lay-out, rear view

QUALITY REPORTING

CODING SYSTEM FOR FAILURE DESCRIPTION

The following information is meant for Philips service workshops only and serves as a guide for exact reporting of service repairs and maintenance routines on the workshop charts.
For full details reference is made to Information G1 (Introduction) and Information Cd 689 (Specific information for Test and Measuring Instruments).

LOCATION

□□□□

Unit number
e.g. 000A or 0001 (for unit A or 1; **not 00UA or 00U1)**

or: Type number of an accessory (only if delivered with the equipment)
e.g. 9051 or 9532 (for PM 9051 or PM 9532)

or: Unknown/Not applicable
0000

COMPONENT/SEQUENCE NUMBER

□□□□□

Enter the identification **as used in the circuit diagram**, e.g.:

GR1003	Diode GR1003
TS0023	Transistor TS23
IC0101	Integrated circuit IC101
R0....	Resistor, potentiometer
C0....	Capacitor, variable capacitor
B0....	Tube, valve
LA....	Lamp
VL....	Fuse
SK....	Switch
BU....	Connector, socket, terminal
T0....	Transformer
L0....	Coil
X0....	Crystal
CB....	Circuit block
RE....	Relay
BA....	Battery
TR....	Chopper

CATEGORY

□

0 Unknown, not applicable (fault not present, intermittent or disappeared)
1 Software error
2 Readjustment
3 Electrical repair (wiring, solder joint, etc.)
4 Mechanical repair (polishing, filing, remachining, etc.)
5 Replacement
6 Cleaning and/or lubrication
7 Operator error
8 Missing items (on pre-sale test)
9 Environmental requirements are not met

Parts not identified in the circuit diagram:

990000	Unknown/Not applicable
990001	Cabinet or rack (text plate, emblem, grip, rail, graticule, etc.)
990002	Knob (incl. dial knob, cap, etc.)
990003	Probe (only if attached to instrument)
990004	Leads and associated plugs
990005	Holder (valve, transistor, fuse, board, etc.)
990006	Complete unit (p.w. board, h.t. unit, etc.)
990007	Accessory (only those without type number)
990008	Documentation (manual, supplement, etc.)
990009	Foreign object
990099	Miscellaneous

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Zambia: Philips Electrical Ltd., Professional Equipment Division, P.O.B. 553 Kitwe; tel. 2526/7/8; Lusaka P.O. Box 1878

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